

Man vs. Driverless Car

We Race an Autonomous Vehicle. Who Won? **TURN TO PAGE 65**

POPULAR MECHANICS

HOW YOUR WORLD WORKS

STUPID

or

AMAZING?

We make the
call on today's
technology

PAGE 92

EXCLUSIVE

AMERICAN F-16s FIGHTING ISIS

In the cockpit with the
pilots the U.S. is training
for battle in Iraq

PAGE 84

TECHNOLOGY
and the
**AMERICAN
TEENAGER**

A Special Report

PAGE 100

PLUS

**Holiday
Gift Guide**

PM-Approved Presents
for Everyone **PAGE 77**

**Build an Old-Time
Wooden Sled** **PAGE 119**

THE FORCE OF MURDER



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G-SHOCK G-STEEL



THE NEW G-STEEL LINE FROM G-SHOCK

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The new G-STEEL line is available in six models, three are pictured here.

From left to right;

GSTS100D-1A4 \$300.00

GSTS100G-1A \$280.00

GSTS110D-1A \$350.00

WWW.GSHOCK.COM/GSTEEL



KITANDACE.COM



NOT FOR YOGA

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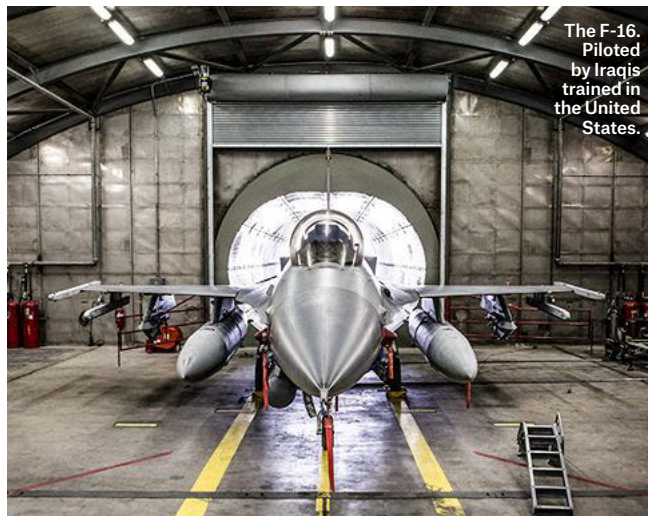
DECEMBER/JANUARY • 2016

COVER
STORY

84 BAGHDAD, ARIZONA

As ISIS rose to threaten their homeland, an elite team of Iraqi pilots came to the Arizona desert to learn to fly American F-16s. After years of training, they're ready to fight back.

BY ELLIOTT WOODS



The F-16. Piloted by Iraqis trained in the United States.



92

STUPID OR AMAZING?

In a year of innovations, we examine some of the most notable to determine what was incredible and what was incredibly dumb, including:

The Drones

The Hyperloop

Wireless Charging

Whiskey Aged
in a Day



100

TECHNOLOGY AND THE AMERICAN TEENAGER

The current generation of kids is the first to be raised wholly in the digital age. They don't know a time without cell-phones, selfies, or the ability to broadcast every thought and emotion. They're more alone—and more together—than humans have ever been before.

BY JACQUELINE
DETWILER

77 THE HOLIDAY SURVIVAL GUIDE

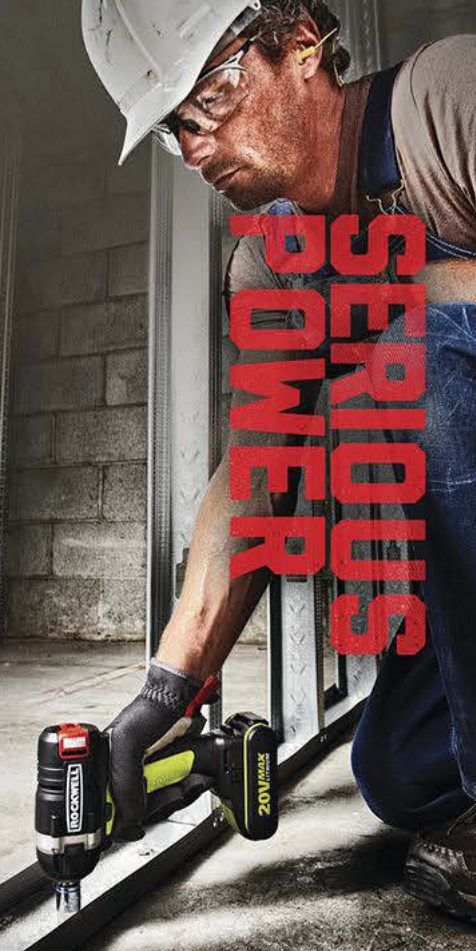
Twenty-nine fantastic and thoughtful gifts. Plus, how to fix your grandma's router, when to make a gift yourself, and where to shop.



59

► **FABRIC:** A special section dedicated to the technology behind the jackets, shirts, and neoprene suits that let you do your best work.

ON THE COVER: Illustration by Tavis Coburn.

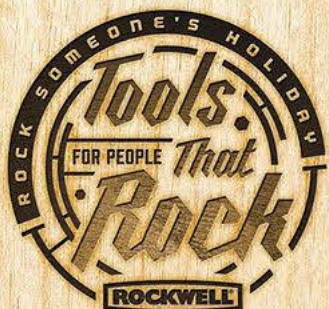


IMPACT WRENCH

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MOTOR**

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From the Editor

CURRENT EVENTS

The other morning, *The New York Times* was splayed out on the kitchen table, covering the places where the varnish has worn away. Our six-year-old son was staring at a photograph on the front page. It showed a scene of chaos in Douma, Syria—a bomb had just exploded, there was fire and smoke in the air, and in the foreground, a young boy ran through the rubble, covering his ears.



"What happened?" our son asked. He does this. He likes to see what we're reading, to know what we know.

My wife and I did our best to explain a horrible, distant war in a way he could understand. He just stared at the photo. Then I told him about a story we were working on for *Popular Mechanics*, about a group of good guys who had come to the United States to learn how to go back and fight the bad guys using fighter jets.

"Will they help him?" our son asked, pointing to the boy in the photograph.

"They're sure going to try," I said. I explained that trying their hardest was all anyone could ask.

He smiled.

That story we were working on, about the fighter pilots, begins on page 84. In it, National Magazine Award winner Elliott Woods writes about a unique, inspiring, and largely unknown United States Air Force program in which Iraqi pilots are trained on American soil to fly F-16s in the fight against ISIS in their homeland. It is a story, essentially, about a group of men who are trying to solve a problem. They are sacrificing years of their lives to do this—one of them sacrificed life itself. The story is a dramatic manifestation of what *Popular Mechanics* has always been about: solving problems. Men solving the problem of war. Great thinkers solving the problem of space exploration. Inventors and creators solving the problems of automotive safety and supersonic air travel, home security and prosthetic limbs, skyscrapers and instant communication. You solving the relatively simple but not unimportant problems of the leak in the roof, the rattle in the engine, the varnish that's worn away on the table where you sit and read the newspaper, your little boy on your knee.

Humans are remarkably resilient and resourceful, and our upward evolution is marked by the problems we solve, both huge and tiny, every day. Maybe the men in the story on page 84 will help solve the problem of the Islamic State terrorists. At the very least, they will try their hardest, and that is no small thing.

RYAN D'AGOSTINO
Editor in Chief



Our cover this month takes its inspiration from a classic created by artist Ed Valigursky for our February 1967 issue, which included a story on the use of the UH-1 Iroquois and other military helicopters in the Vietnam War.

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How to get the most out of your month.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		DECEMBER				
6 The first night of Hanukkah, celebrating when a one-day supply of oil lit a temple for eight, the world's first lesson in energy efficiency.	7 The 74th anniversary of the Pearl Harbor attacks. Take a moment and teach the kids a little American history.	1	9 Today is the best day to put up the Christmas lights. It's not yet too cold, or too late or too early.	10 Ron Howard's whaling epic <i>In the Heart of the Sea</i> premieres.	11 	5 Get out there and relish the labor and reward of chopping down your own Christmas tree.
27 	28	15	23	31 	18 Steel yourselves. <i>Star Wars: The Force Awakens</i> hits theaters.	
10 The Golden Globes airs on NBC.	4	IN NEXT MONTH'S ISSUE We go behind the science of the Academy of Motion Picture Arts and Sciences. Plus, the most powerful things on earth.	30	New Year's Eve	25 Christmas Day	2
24 	18 Martin Luther King Jr. Day. Use the day off to do some volunteering. Find a place near you at nationalservice.gov/mlkday .	5 The February issue of <i>Popular Mechanics</i> hits newsstands.	6	7 	1 On New Year's Day, the NHL holds its annual outdoor hockey game, the Winter Classic, in Boston. Most comfortably viewed from your heated home.	9 Mark the edges of your driveway with stakes or reflectors before having it plowed. The stakes may get damaged, but at least the lawn under the snow won't.
31 The final day of the Winter X Games in Aspen. Tune in to see the crowning of the next Shaun White.	25	12	13	28 	15 Michael Bay's cinematic account of the 2012 Benghazi attack, <i>13 Hours: The Secret Soldiers of Benghazi</i> , is released.	29 The ship-in-a-storm thriller <i>The Finest Hours</i> premieres to make you feel bad for complaining about the cold.
		19				
		26				

SAT
12/5

THE KEY TO CHRISTMAS TREE SURVIVAL

12/5 Get your tree early in the month. When it comes time to set it up, cut the base again to expose fresh wood. (Use the excess for an easy project, see page 13.) Then prop it up in a stand like the one on page 74.

THURS
12/3

A NEW YEAR'S EVE KID HACK

THURS
12/31

Let the little kids participate in New Year's fun without keeping them up past midnight: When it's near bedtime, set the oven clock to 11:58 and cue up last year's ball drop on YouTube. Have your own countdown and let them bang pots till they're all tucked out.

SUN
1/24

THE TV RECOMMENDATION

SUN
1/24

Thirteen years after it went off the air, we once again get the pleasure of watching *The X-Files*—and a pensive Gillian Anderson walking through dimly lit corridors, flashlight in hand—in a six-episode miniseries event.

Reader Pages

READER TIP: ABATING THE HELL OF ATTIC REPAIR

Your story "Home Ownership, Oh, Joy" (October) reminded me of when my sister and I insulated our mom's attic in the '50s in the heat of an Ohio summer. I remember saying we needed a rain-storm to cool things off. So I put a lawn sprinkler on the roof and in ten minutes we were cool for the rest of the job. Also, get an estimate before doing it yourself. After my neighbor redid his attic, he realized he could've had it done commercially for less than he paid for the insulation.

Robert G. Henning
Los Lunas, New Mexico



AN UPDATE: WE KNOW HOW TO PICK 'EM



When we selected Anurudh Ganesan and Olivia Hallisey for our Next Generation Breakthrough Awards (November), they were Google Science Fair regional finalists. Since then, Ganesan has won the Lego Education Builder Award for the Vaxxwagon, his refrigerated vaccine-delivery system. And Hallisey claimed Google's Grand Prize for her revolutionary Ebola test along with \$50,000 to put toward college—presumably, whichever one she wants.



HOW TO SPEND MORE TIME ON YOUR PHONE

In case you haven't had enough, you can now keep up with us on Snapchat. Follow "PopMech" on the app to get dispatches from our offices and quick tips. Or scan the code above to be taken directly to our feed. (If you are looking for ways to spend less time on your phone, turn to page 42.)



IF SITTING AND LISTENING IS MORE YOUR SPEED

Download our podcasts. We've got two! *How Your World Works* is about just that, covering the inner workings of the latest science and technology news. *The Most Useful Podcast Ever* features experts to make everything you do—like riding a bike to work and sleeping—better, easier, and more fun.

Letters to the editor can be emailed to editor@popularmechanics.com. Include your full name and address. Letters may be edited for length and clarity. **CUSTOMER SERVICE/SUBSCRIPTIONS** online: service.popularmechanics.com; email: popcustserv@cdsfulfillment.com; mail: Popular Mechanics, P.O. Box 6000, Harlan, IA 51593; **subscribe**: subscribe.popularmechanics.com.

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Reader Pages (Cont'd.)



REMEMBER:

We give \$100 for reader projects that we publish, and \$50 for original reader tips that we run. You can send both to editor@popularmechanics.com.

A RAISED GARDEN

Winters are rough up in Laval, Quebec. But the summers and on into fall can be outright idyllic. To get the most out of the warm months, Simon Richard's wife wanted a garden. So over the course of a weekend in May, he built her the ultimate setup. A criminal lawyer by day who inherited handiness from his engineer father, Simon tends to go a little overboard with his projects. Take the 8 x 8 cedar-enclosed garden-box's built-in

irrigation system, which he connected to his regular lawn-sprinkler system, as an example. He also included a concrete-tiled base to keep errant gophers from getting in. Then, because he had some scrap wood left over from the project, he built an end-grain coffee table. The Richards' new garden yielded tomatoes and zucchini this past summer. And while it may be sitting dormant through a Canadian winter, it's so well built it will be serving them for springs and summers on end.

**PROJECT
OF THE
MONTH**



ONE MORE WAY TO MAKE GIFT GIVING EASIER

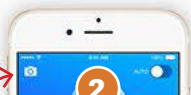


Our complete gift-giving survival guide starts on page 77 with a lot of useful tips and gift ideas. Now, with the help of Shazam and your smartphone, you can actually purchase our recommendations, immediately streamlining how quickly you can show someone that you care. Here's how to do it:



1

Open the Shazam app on your smartphone. You probably already have it downloaded. It's the same one that helped you come to terms with the fact that, yes, you do like that Macklemore song.



2

In the app, tap the small camera icon in the upper left corner.



3

Aim the viewfinder at the Shazam icon on the Kids' Toys page of the gift guide (page 83) and you'll be taken to an even larger collection of great gifts that you can buy. Make sure you allow enough time for shipping. We haven't worked out drone delivery yet.

Upgrade your style, **inside & out.**



Upgrade your vehicle lighting with **Philips Vision LED Bulbs**. Their revolutionary LED lighting technology gives you **brilliant, 6000K light** and a unique, **high-tech style** for interior and exterior lighting applications.

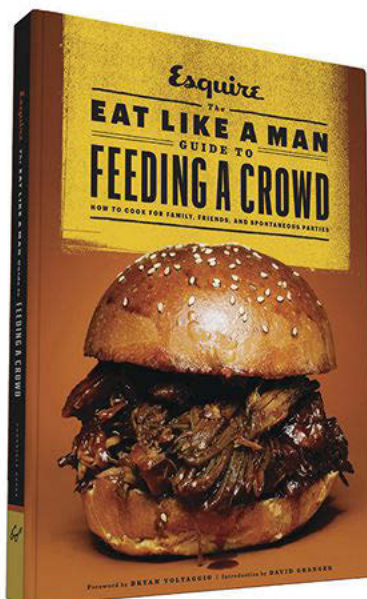
Plus, thanks to Vision LED's **12+ years lifetime**, once you put them in, you'll likely never have to replace them again.

innovation ✨ you



To learn more, visit
www.philips.com/visionled

PHILIPS



The only cookbook you'll ever need when the party is at your place!

The ultimate resource for guys who want to host big crowds and need the scaled-up recipes, logistical advice, and mojo to pull it off, whether they're cooking breakfast for weekend guests, producing an epic spread for the playoffs, or planning a backyard BBQ. Includes more than 80 recipes, with favorites from chefs such as Tom Colicchio, Mario Batali, and Bryan Voltaggio.



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Shop Notes

EASY
WAYS TO
DO HARD
THINGS

SWEEP SNOW WITHOUT RUINING A BROOM

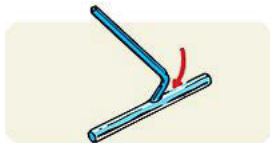
When using a broom to clear light snow, wrap the bristles in a burlap sack or sturdy tote bag. Secure the sack around the handle with a rubber band. This makes for a more effective sweeping tool and also prevents bristles from being damaged.



Homemade Cleats Ease Snow-Chain Installation

PUTTING CHAINS ON TIRES can be a hassle because the tire pins the chain during installation. There is a way around this problem: Take a pair of wide boards and cut a long bevel on one end of each, so a vehicle can easily drive onto them. Then cut eight lengths of 2 x 4 equal to the width of the boards. Nail four to each board, spaced so the cross-links of the chains can rest in between. To install chains, park the vehicle with its tires resting on the cleats. This leaves the chains loose for a smooth installation.

HEX-KEY IMPROVEMENTS



HANDLES HELP HANDS HOLD HEX KEYS

L-shaped hex keys are literally a pain to turn. Transform lengths of small-diameter pipe into T-handles to make them more comfortable: Cut pipe into a 3-inch length and drill a slot in the middle, sized for a hex key. Feed the short side of the key into the hole so its long side extends perpendicular. Fill the pipe with epoxy putty to secure the handle.



BUT THE BEST HANDLE IS A POWER DRILL

When assembling a project with lots of fasteners that need to be driven by hex keys, it's handy to have a set of hex drill bits. Alternatively, a bit can be improvised. Nate of IkeaHackers.net suggests removing the short end of a hex key—a hacksaw will do the trick—to produce a straight shaft that can be chucked and driven by a power drill.



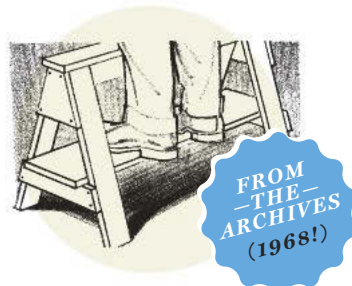
ANOTHER USE FOR A CHUCKED HEX KEY

Justin Simonson of Ritzville, Washington, suggests a clever way to quickly secure screw hooks and eyes that he first encountered in "The Home Shop Machinist" newsletter. Insert the long end of a hex key into the chuck of a power drill, then slip the short end through the eye or hook. Engaging the drill—slowly—turns the key, tightening the screw.



Improved Multipurpose Handle

Many things in life can be annoying, including a heavily used container that doesn't have a handle. Make one: Tighten a sufficiently large C-clamp on the container.



Make a Wood Sawhorse a Bit More Useful

A wood sawhorse with crossmembers between the legs becomes a stepladder when you set a board on them. It'll offer only a few inches of height, but sometimes that's exactly what's needed.

Let Eggshells Solve Their Own Problems

When cracking eggs for a delicious meal, ending up with a shard or two of eggshell in the white is inevitable. Rather than using the fingertip pin-and-drag technique, scoop it out with another piece of the shell, which cuts easily through the gooey egg white. And consider cracking eggs on the countertop, instead of the edge of the bowl—it cuts down on errant shards.

A BOTTLE OPENER FOR THE WORKSHOP

Take a bit of scrap board easily gripped by hand and drive a nail through it so the head remains about a half inch above the surface. Bend the shank back against the opposite side of the board. To open a bottle, use the nailhead to grip the cap, then pull. Assemble before consuming beer.



We are always looking for clever solutions to everyday problems. Email your shop notes to editor@popularmechanics.com and we'll pay \$50 if we print them.

Crescent Wrench Caliper

When drilling a hole for a nut-and-bolt assembly, quickly determine what size bit to use by tightening a Crescent wrench around the bolt, then finding the drill bit that fits snugly into the jaws at that width.

Improve Wireless Router Effectiveness

Wireless routers connect computers and an ever-growing list of vital home devices to the Internet and to each other, so when their signals get patchy it's a nightmare. Two quick improvements help. First, plug the router into a cheap electric timer set to briefly turn it off—effectively resetting it—every night while the house sleeps. Then, on routers with multiple antennas, position the antennas perpendicular to each other. This provides the best chance for the wireless signal to align with devices' antennas.



Christmas Tree Coasters

Contributing editor Richard Romanski cuts drink coasters from tree trunks (see them at northsalemdesign.com). Use your Christmas tree to make your own—a fresh cut from the trunk will also keep it vibrant and healthy longer into the holiday season. An ideal coaster thickness is about a half inch, so a cut 7 or 8 inches off the bottom of the tree easily yields a full set. For stability, clamp the cut portion of the stump between two 2 x 4s, then use the clamp as a handle to carefully slide it through a band saw. In time the wood's natural moisture will evaporate and the coasters will crack, but by then you'll have rung in the new year.

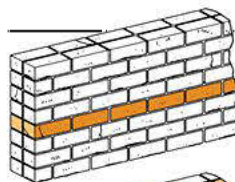
The Bricks in the Wall

GETTING HEADERS AND STRETCHERS from hod* to course and wythe isn't as simple as it sounds. When building a brick wall, a mason uses a particular formula for orienting bricks, called a bond pattern. Today, brick is rarely load-bearing, but when bonds originated their purpose was to align bricks and vertical joints for structural integrity. They persist in non-structural uses because of their pleasing aesthetic qualities.

THE WALL

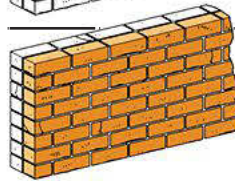
COURSE

A horizontal unit of wall, one masonry unit high.



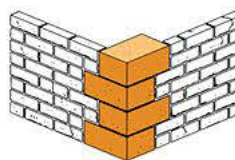
WYTHE

A vertical unit of wall, one masonry unit thick.



QUOIN

A decorative treatment for the corner of the wall, consisting of brick or stone different from that used for the face of the wall.



THE BRICKS



STRETCHER



HEADER



SAILOR



SOLDIER

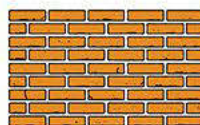


ROWLOCK



ROWLOCK STRETCHER or SHINER

THE BOND PATTERNS



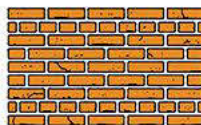
RUNNING BOND

Only stretchers are used. Vertical joints are offset for strength. Easy to install, this is the most common bond used today.



STACK BOND

Only stretchers are used, but vertical joints are aligned. The weakest of the commonly used bonds, stack bond requires significant additional support.



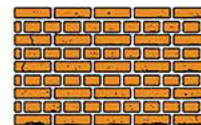
COMMON BOND

Periodic header courses break up rows of running bond. The header courses require a cut three-quarter-length brick at the corners.



FLEMISH BOND

Each row alternates headers and stretchers. Multiple stretchers can come between headers: A pattern with three stretchers between headers is called garden-wall bond.



ENGLISH BOND

Rows of headers and stretchers alternate, with headers centered above stretchers, and stretchers aligned vertically. The English cross bond or Dutch bond variation offsets the stretcher rows.



*A brick hod is used for carrying brick. In the wrong hands, it can be quite dangerous, and should only be hoisted by individuals of true strength and cunning.

WITH THANKS to Brian Trimble of the Brick Industry Association.

Great New Stuff



The things you need in your life this month.



The interior of the box's lid is made of Horween leather, dyed and tanned in Chicago.

01

SHINOLA + CRISLOID DOMINOES SET

Rhode Island-based Crisloid has been making games since 1948, which explains the reassuring heft you feel when you stack these dominoes. Teach someone to play and the black resin tiles become rich with significance. **\$230**

02

ELECTROLUX MASTERPIECE COLLECTION BLENDER

A simple, brilliant idea: The bottom of this blender is tilted 5 degrees, so the motor doesn't need force to create a strong vortex—gravity brings all the ingredients into the blades. Late-night milk shakes are as delicious, but quieter. **\$349**

03

STANLEY NESTING COCKTAIL SET

Every camper does the whiskey flask. Try campfire manhattans and you and your party will agree that the bitters and vermouth were worth the extra weight. **\$35**

04

ROKU 4

Spot a billboard ad on your commute, open the Roku smartphone app, and set a reminder to notify you when that movie is available (and free) to stream. Hit a button on top of the box to ping a lost remote. Plug headphones into the remote to keep the kids from waking up. Those details—and not the coincidence, as far as we're concerned, that Hearst, our parent company, is an investor in Roku—make this the streamer we want next to the 4K TV we're saving up for. **\$130**





Turn on the lights.

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What's on my
calendar today?

Who is Nikola Tesla?

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HOW YOUR WORLD WORKS

TECHNOLOGY

THIRTY-SIX HOURS AT THE MOST IMPORTANT HACKATHON ON EARTH

Here's what happens when 400 prodigies and 1,500 cans of free Red Bull descend on Silicon Valley.

BY ALEXANDER GEORGE



In two days, Timothy Su, 21, created an app that exchanges money between payment platforms, such as Venmo and Bitcoin.

Even inside the Computer History Museum, August in Silicon Valley is too warm for a hoodie, so most of the 400 young engineers and programmers gathered here are wearing graphic T-shirts and baggy gym shorts or cargo pants. Many wear running shoes, but some are barefoot, and almost all have slumped posture and unstylish haircuts. Speakers on tripods at the edge of the room play dubstep, bass-heavy electronic music that reminds one of the sound effects from video games. “It’s like you’re a machine!” one engineer exclaims. Work surfaces are covered with oversize monitors, ergonomic mice, empty cans, and Sun Chips crumbs. Every item in sight serves the sedentary, stress-fueled, often solitary nature of inventing the future with ideas and a keyboard. This weekend, however, is anything but solitary.

This is Hack the Planet, an especially prestigious hackathon. But that word, *hack*, doesn’t mean the same thing it does in news stories about data breaches at Bank of America or Ashley Madison. In the context of this event and the thousands like it that take place around the world, to hack means to create: A hackathon is an invention competition with a time limit. Participants have 36 hours to make a gadget or an app that improves lives.

As for what makes this event more prestigious than most: Major League Hacking, the organization that hosts Hack the Planet and sanctions more than 150 hackathons every year, invited only college and graduate students and a handful of high schoolers who demonstrated both the creativity to come up with unusual ideas and the coding and engineering acumen to execute them. Jon Gottfried, an MLH cofounder, explains that he and the commissioners call up past winners and fanatical participants from other hackathons but also entrants like Stefanie Cohen, 23, who’s known for creative hacks involving visual art. The builders who meet these criteria are exceptional, which is why sponsors such as Microsoft, Oculus, and venture-capital titan Andreessen Horowitz give Major League Hacking the cash to rent the second floor at the Computer History Museum and hand out soldering guns and Bluetooth transmitters. In return, those companies get to scout for new hires. For the few who don’t already have work lined up, meetings here often lead to full-time jobs after graduation or lucrative summer internships.

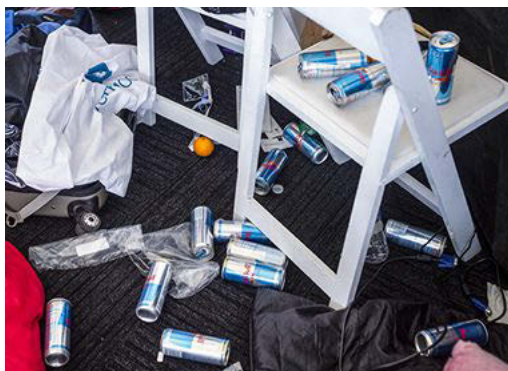
By 11:00 Friday night, a quiet chaos that will last through the weekend has descended over the hall. Some programmers work alone, but some form teams. A few met weeks before tonight through the event’s Facebook group. Others met at the team-building session a few hours ago, at which one Hack the Planet organizer wrote participants’ ideas on a whiteboard.

Brijen Thananjeyan, Krishna Bharathala, and Jeffrey Chen, all 19, went to high school together. They take turns strapping an Oculus Rift headset around their heads, testing the virtual room they’re designing in which users can draw on the walls. “The marks are pink,” Bharathala says. “And I can’t figure out how to change them.”

Jenna Seco, 20, and Dan Stepanov, 24, who are dating, work with three other people on a calculator app that, when given the right number sequence, unlocks a secure messaging system for use in ISIS-controlled territories. At the next table, Shariq Hashme, 21, Justine De Caires, 17, and Anthony Lobko, 19, are building a noninvasive glucose meter for diabetics, but the lightbulb that sends light through the finger to the sensor keeps melting



Above, Fernando Faria, 22, tests an Oculus Rift system built by another hacker that teaches motor skills to people with cerebral palsy. At left, branded swag and hackathon fuel (Red Bull).



HACKED APPS

Impressive creations born at previous hackathons.



GroupMe

A group-messaging app that preceded now essential workplace chat providers, this was built at the TechCrunch Disrupt Hackathon in 2010. Skype bought it a year later for an estimated \$43 million.



WorkFlow

Created at the 2014 MHacks at the University of Michigan, this app can trigger a set of functions under preset conditions, such as automatically uploading photos. It won an Apple Design Award.



Cosmos

A team of four built this text-based Web crawler at a University of Michigan event and is now expanding it at an accelerator so exclusive that fewer than 1 percent of applicants are admitted.

the adhesive holding it in position. More experienced engineers stand by to help competitors who are stuck, easily spotted by their heavy sighs, rapid foot tapping, and muttered profanity. The mentors, barely older than the competitors, point out problems in their code.

A few competitors spend the entire weekend awake, like Shane Engelman, 27, a former U.S. Air Force serviceman, or at least try to, like Aki Gao, 21, who drank five Red Bulls within the first two hours and 13 more over the course of the hackathon. Most sleep intermittently, either on pads in gender-segregated, darkened conference rooms or under the main room’s fluorescent lights. Many of those napping are wearing Pebble-branded pajamas or resting on Microsoft-branded neck pillows—freebies.

Sunday morning, time is called at 10:00, and the programmers set up their creations like students at a science fair. Four finalist judges, veterans of the software and hardware industries, are looking for functionality, technical complexity, creativity, and whether they’d actually use the end result. They give top honors to an app that lets you make music with your voice while waiting on hold on the phone. Sponsors, who all offer their own awards, announce other winners. BMW’s motorcycle division has the most coveted prize: a trip to the Munich headquarters to pitch the idea to management. That one goes to an app that links experienced motorcycle owners with curious newbies.

Participants are, or pretend to be, indifferent to the results. When asked whether he was upset about not winning the BMW prize, Engelman says, “That’s not why I come to these things.” Watching the intense collaboration happening around the room, you can see his point. A trip to Germany might be the highlight of a young adult’s life, but the social communion among 400 people in the same place who enjoy talking about nodes and API—that is why they come. It’s the chance to code and hack and solder, yes. Of course. It’s the opportunity for internships and job offers. But really, they come for the humans.

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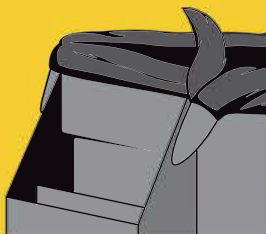


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A EULOGY FOR THE HUMVEE

In 2015 the Army awarded truck-maker Oshkosh Corporation a \$6.75 billion contract to replace the U.S. military's longtime workhorse, the High Mobility Multipurpose Wheeled Vehicle, with the newer, fancier Light Combat Tactical All-Terrain Vehicle (L-ATV). One veteran would like to say a few words. **BY ROBERT VRABEL**

I left home for the Army on my 18th birthday. Overnight I found myself in the middle of an Alabama summer. There were drill sergeants screaming in my ears and I was doing push-ups until my face was buried in the thick red mud that the state is famous for. These trials came as no surprise to me. The Humvee, however: a surprise. I'd never in my life driven anything larger than a coupe, so taking the wheel of an enormous vehicle I'd seen only in photographs was terrifying. Over time, though, driving the Humvee became second nature. That's how it happens for most soldiers.

Did the Humvee have its problems? Of course. It had an annoying habit of not starting in the cold, so during an overnight blizzard in the mountains of Bosnia, Private Yours Truly was tasked with starting 11 of them every hour on the hour to keep the glow plugs warm for a morning mission. It was also notorious for both heater and air-conditioner breakdowns, leaving soldiers to face the elements with nothing more than our issued equipment.

That said, in its 30-plus years of service, the Humvee has rarely failed entirely. It's carried troops over mountains and deserts, through mud and forests. I witnessed troops using it to rush to the aid of outnumbered soldiers, firing support from a mounted MK 19 40-mm grenade launcher. I watched it take the brunt of a detonated IED so that humans didn't. It wasn't always perfect, but it could be relied on to adapt to the mission. That's about all you can ask of any soldier, and as soldiers go, the Humvee was a good one.



An optional hybrid diesel-electric powertrain, called ProPulse, improves fuel economy by up to 20 percent over the Humvee, and powers a generator that can provide 120 kilowatts of AC power for external computer and communications devices in the field.

The L-ATV is practically a mobile command center: Each vehicle is equipped with multiple frequencies of radio communications, satcom, surveillance cameras, and a vehicle-to-vehicle intercom system that can be modified from mission to mission.

Because of the high number of IED casualties during the Iraq and Afghanistan wars, the military began bolting steel plates on Humvees, eventually relying more on mine-resistant vehicles, such as Oshkosh's Mine-Resistant Ambush Protected vehicle (MRAP). The L-ATV offers similar protection to an MRAP, but at roughly two-thirds the weight.

Springs and dampers in the suspension allow the L-ATV to move 70 percent faster across terrain than current military vehicles. The suspension is also adaptable. It can lower the L-ATV so that it fits into transports designed for Humvees.

THE NEW RECRUIT

Behold:
The L-ATV.

AN IDEA
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THE IPHONE-BASED DRIVER'S LICENSE

Imagine you're in another country—deep in agave territory in Central America, say—when you realize the location of your passport is not the same as the location of your body. You're riding a bus. The passport? On a bar next to a plate of fish-taco crumbs. Option one: Panic. Option

two: Download the passport app on your iPhone. No problem. For now, option two is not possible, but the Iowa Department of Transportation, of all agencies, is ushering us into an idyllic future in which it is. IDOT has partnered with Morpho-Trust USA, the nation's primary license manu-

facturer, to pilot a mobile driver's license (mDL) that works on any smartphone. To display the ID, a phone will require facial recognition, a fingerprint, or a code. Covert security features within the software, as well as a bar code and a hard-to-duplicate rotating photo, will make replicating or faking

an ID close to impossible. And if you lose your phone, all you have to do is report it to the DMV and all identifying information will be wiped immediately. The ID system is currently in tests, which IDOT expects to expand more widely this year. Here's hoping passports are next.

—KATIE MACDONALD

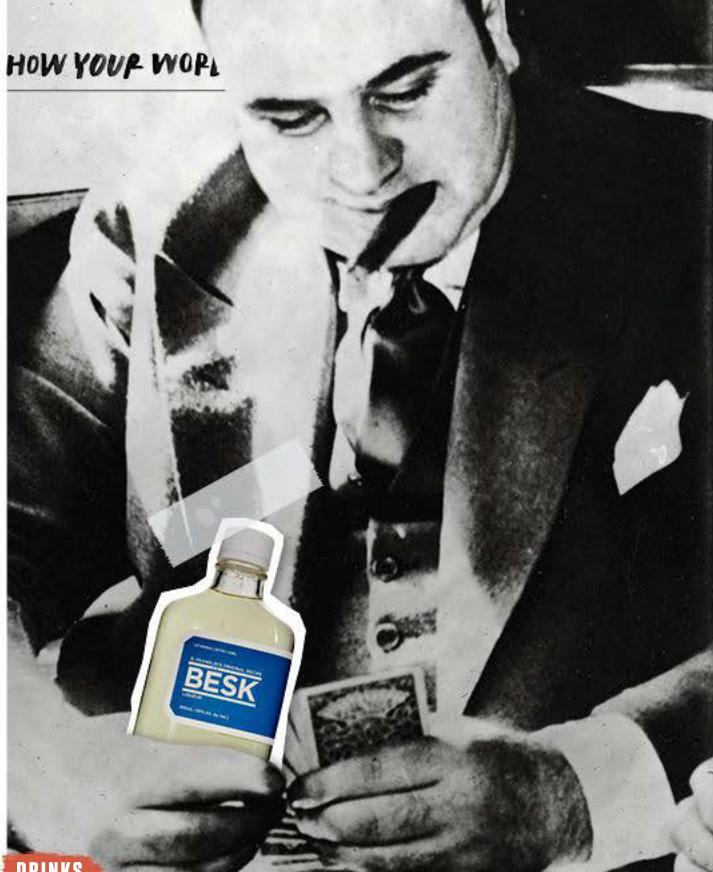
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DRINKS

CHICAGO'S NASTIEST BOOZE

The city's worst drink is also its most beloved. Try it. You'll maybe like it.

BY FRANCINE MAROUKIAN

There's something you should know about Malört, but it's something you can't truly understand until after your first sip: It tastes terrible. One person described the flavor as "burnt Band-Aids." Another compared it to "ashtray water." To Chicagoans, the drink is a matter of history, pride, and pain. Malört is the Swedish name for wormwood, a wild plant native to the Northern European mountainsides and one of nature's richest sources of alpha-thujone, a chemical compound believed to have hallucinogenic power. When used in absinthe, another wormwood spirit, thujone was believed to foster creativity as well as insanity—the reason absinthe was banned from legal production for almost a century. Not that that mattered in Chicago, where Malört, a relic of the city's great Scandinavian immigration, has been made since Prohibition.

In the early '30s, Carl Jeppson offered his fellow settlers a taste of home with Jeppson's Malört, the original palate-peeler, which, after the mid-century, languished as a local novelty—typically offered to out-of-towners as a dare—until craft-cocktail-makers decided it was time for a revival. To limit competition, Jeppson's trademarked the name Malört in 2013, but that didn't stop Brenton Engel, founder of Chicago's craft distillery Letherbee, from producing a neotraditional version he calls Bësk, the Swedish word for bitter. Thanks to him and other distillers, you can find versions of Malört in many Chicago

bars, either as shots or in cocktails. (You can also buy Bësk online. Try it with grapefruit soda.)

A cult moonshiner who once delivered unlabeled jars of hooch to some of Chicago's trendiest restaurants and bars, Engel has the experience and interest to bring harmony to wormwood's twofold identity: enough bitterness to pass as the same old punishment with enough polish to be newly palatable. He started with a very simple, custom-made still, bought with a \$15,000 inheritance from his grandmother, and prepared the spices with a coffee grinder. "You learn so much more about your craft if you evolve it from scratch," he says. "It's definitely a difficult path to follow, but it teaches you to be more talented as a craftsman."

Engel developed a commercial scale of a collaborative small-batch recipe from friend and fellow bartender Robert Haynes. Adhering to the Scandinavian legacy of honesty, clarity, and value—reflected in the minimally labeled bottle that allows a full view of the 100-proof spirit within—Engel is committed to an all-natural process. Bësk is constructed from only alcohol, water, sugar, botanicals, and dried spices. And a lot of skill. It starts with a very pure, clean, neutral spirit. The complexity—some might call it weirdness—is achieved through maceration, done by soaking raw materials in alcohol without heat until the spirit absorbs the flavors.

"Flavor-wise, we wanted Bësk to break new ground," Engel says. "We all agreed that it should be bitter and wormwood should be a primary flavor. We wanted to make a spirit that was more than just a simple, singular flavor experience. We wanted to make a spirit with layers."

The wormwood that bestows Bësk's bitterness is wildcrafted in Croatia and Bulgaria. Star anise gives the drink some sweetness or candied flavor; grapefruit adds freshness and brightness. But the key is balance, and to achieve that in such a bitter spirit, Engel adds his own blend of secret ingredients.

True to his roots, Engel packages Bësk in a bottle shaped like a moonshiner's flask, portable enough to share the occasional nip and power through his city's Baltic-like winters. It's an easy way to say Welcome to Chicago.

THINGS YOU
MIGHT
ENCOUNTER
AT THE BAR



The Cha-chunker

When Eben Freeman opened the bar Genuine Liqueur in New York City, he was inspired by California bodegas as well as by a cocktail

called the Bulldog—a margarita with a beer overturned in it. He started building drinks that are classic minibar nips perched upside down in cans of soda and beer. But to get the bottle, straw, and garnish positioned just right, Freeman found he needed to widen the mouth of the cans. He had a metalworker friend modify an arbor press, a machine used to rivet leather, with a conical stainless-steel bit

that would crush a can's opening inward to create a smooth 1¼-inch circular hole. Then the metalworker kept improving it. Now, the machine, which Freeman calls the Cha-chunker for the sound it makes, has a spring on the handle for easy retraction and a ring to hold cans in place. It's almost as pretty as one of the cocktails it makes, and at least twice as dangerous.

—LARA SOROKANICH



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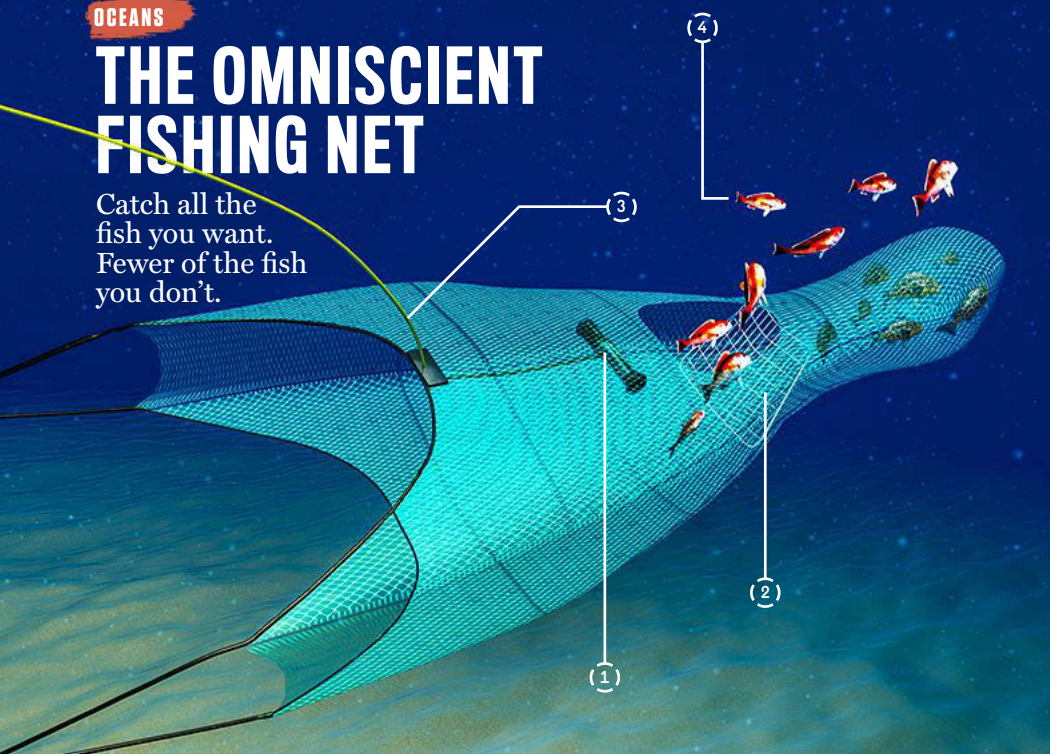
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Fishing nets haven't changed much since Jesus told Peter to favor the right side of his boat. You put the net in the water. You haul it in. You see what you got. Problem is, accidentally catching endangered fish can decimate their populations. And a catch containing prohibited fish can lead to a heavy fine for the fisherman. SmartCatch, a sustainable-seafood technology company, has developed a solution: a waterproof, self-lighting camera and a trawl net you can control from afar. Now, fishermen can finally see what they're catching before they catch it, which might even impress Jesus. —CAMERON JOHNSON

How It Works



1. The Camera

Fish can navigate in the darkness 500 fathoms under the ocean. Cameras, not so much. The DigiCatch is equipped with one rotatable high-definition camera with two video sensors that can be used simultaneously for color and black-and-white viewing. It also has LED lights capable of producing 40,000 lumens and instruments that measure salinity, temperature, and depth.

2. The Net

If a fisherman sees that he is about to snag the wrong kind of fish, he'll deploy the diverter on the SmartNet, which acts like a trapdoor. This will collapse a section of the net, allowing undesirable sea creatures to escape. Any fish already caught will remain trapped in the far end.

3. The Connection

Running up from the trawl net to the deck is a high-speed digital cable that

allows for real-time viewing of the camera and manipulation of the net. The onboard end of the cable transmits to the computer via Wi-Fi, so the crew doesn't trip over cords on deck.

4. The Fish

According to the National Oceanic and Atmospheric Administration, 17 percent of all fish caught are bycatch, or accidental haul. Most of these fish (also, sometimes, birds) die.



ASK A TECH EDITOR

CAN MUSIC SOUND GOOD IN A SHOE-BOX APARTMENT?

Something about an intimate bar makes music sound rich and stirring, but a tiny apartment doesn't have the same effect. Any speaker configuration that fits in the space usually sacrifices acoustics. I have Sonos speakers (\$199 and up) in my pint-sized Manhattan walk-up because, in addition to producing stellar sound, they get periodic software updates that actually make them sound better with age. The latest add-on, Trueplay, is an idiot-proof way to optimize the sound for a specific space. Plant a Sonos speaker wherever it ties the room together, open the app, and follow the video.

As the speaker makes laser noises (*pew! pew!*), walk around the room's perimeter waving your phone up and down. The app uses the phone's microphone to determine which frequencies are getting accentuated or absorbed by the decor, and then adjusts which amps, tweeters, and woofers it needs to turn up or down. Your bedroom-slash-kitchen-slash-bathroom will sound like a concert hall. It's uncanny.

—ALEXANDER GEORGE

STAR WARS:
A Brief Recap

Episode I The Phantom Menace: Queen Amidala escapes with Obi-Wan, meets Anakin, a slave who has the force. Jar-Jar. A battle. The good guys win. **Episode II Attack of the Clones:** Ten years later. The Trade Federation builds an army. Anakin loses an arm. Marries Amidala. **Episode III Revenge of the Sith:** Anakin doesn't make Jedi Master. Turns to the dark side. Gets a new name, terrible burns, a respirator. Becomes a dad to twins (Luke and Leia), also a widower. **Star Wars:** Grown-up Leia leads rebels in civil war. Han Solo. Chewbacca. Luke learns the force, blows up the Death Star. **The Empire Strikes Back:** The Empire strikes back. Luke meets Yoda. Han frozen. Luke loses a hand. **Return of the Jedi:** Leia wears a gold bikini. Han rescued. Vader kills the Emperor, saves Luke, dies. Luke escapes. Tiny bear people celebrate. **Episode VII The Force Awakens:** In theaters December 18.



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Q



How many AA batteries would it take to start a car?

A **AA? WE PREFER AAA**—as in the American Automobile Association, which, for a nominal yearly membership fee, will gladly send a mechanically inclined gentleman in a well-equipped truck to start your car for you if you ever get jammed up with a dead battery. But maybe you're stranded outside an Eveready warehouse with no phone service or you're just determined, for reasons of your own, to get all MacGyver with it. Here's what you need to know:

No. 1: This is an impractical idea. It would be difficult, expensive, and possibly dangerous. We do not recommend it. No. 2: It is possible. Let's start with what we might call the "perfect case." Professor and automotive engineer Giorgio Rizzoni of Ohio State University lays out the following assumptions: The car employs a standard 12-volt battery, and the temperature is above freezing. Starting the engine will require 250 amps for a half second, and the most current a 1.5-volt AA battery can produce is 10 amps. Given the above, you'd need to start with a string of eight AAs to get your necessary 12 volts. However, to produce the necessary current (250 amps) you'd need 25 parallel strings of eight AAs ($25 \times 10 \text{ amps} = 250 \text{ amps}$). So, in a strictly theoretical world, 200 AA batteries ought to be able to start a typical midsize car—once.

Stepping out into the real world (which we really ought to do more often) we need

to account for an inopportune property of electrical connections: They bring with them something called resistance. In short, every connection demands more current, and if you're soldering, welding, wiring, whatever, 200 AA batteries together, then hooking them up to your car's starter motor, you're going to need a lot more juice along the way. That means more batteries. How many? Lots. The calculations are too complex for this space, to say nothing of our liberal arts background, and involve a bit of technical guesswork. But various reckonings suggest it might actually require anywhere from 1,200 to nearly 5,000 AAs in total to crank up old Bessie. Given that, you'd be better off selling the batteries and using the money to buy a car that starts.



When lightning strikes the ocean, how many fish die?

Fewer, perhaps, than die when one dumps a Pontiac with a trunkful of AA batteries into the ocean out of frustration that the bastard still won't turn over. Indeed, fish tend to lead short and brutish lives, but lightning is way down on the list of threats they face.

For one thing, and this may surprise anyone who has seen the intro to *Gilligan's Island*, lightning storms at sea are not all that common. The farther offshore you go, the rarer they get. Ask a scientist why this is and you'll hear a variety

of theories that, when you sum them up, equate roughly to "beats us." In any event, salt water is a good conductor (i.e., it has low resistance), which means that when lightning does strike the ocean, it spreads quickly on the surface and disperses. Don MacGorman, a senior scientist at the National Oceanic and Atmospheric Administration's National Severe Storms Laboratory, says that unless a fish is right underneath a strike and swimming at a depth of less than 10 feet or so, it's likely safe. Consider this, though: A 2013 NOAA study found that 64 percent of lightning deaths since 2006 occurred while people were participating in "leisure activities." The deadliest? Fishing.



Will we ever have Star Trek-style teleporters? How will they work?

Never say never, though from today's scientific vantage point, it's hard to see how we'll bridge the gap from the dreaded depredations of Boarding Group 4 to the breezy convenience of "Beam me up, Scotty." But, hey, let's dream for a minute.

There have, in fact, been successful experiments in something called quantum teleportation, in which the information contained in one atom is transferred to another, effectively replicating the first atom in another place. "That would be fine in a *Star Trek* sense," says Steve Rolston, codirector of the Joint Quantum Institute at the University of Maryland, "except when I do it with *Star Trek*, I have to do it with however many atoms are in you." Which, Rolston adds, amounts to "more information than we would ever have any possibility of keeping track of."

Even if that hurdle were overcome, human teleportation would be quite a bit messier than the shaft of swirling jelly beans seen on TV. You'd need some kind of medium on the arriving end—a blob of carbon, oxygen, nitrogen, etc.—just waiting to become your winsome smile, gruesome toenails, and everything in between. And what would be left on the other end? Another blob. Gross.

Fear not, however. Professional futurist Michael Rogers argues teleporters will soon be unnecessary, thanks to the developing field of "telepresence," in which far-flung robotic avatars connected to our senses will enable us to "be" anywhere we like without ever leaving home. At last, a truly practical use for all those AA batteries.



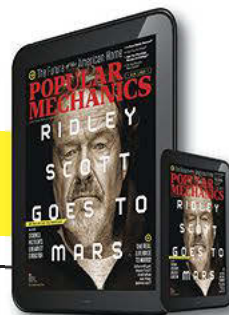
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WHAT'S BEHIND THAT WALL?

The Popular Mechanics guide to cutting, drilling, and mounting—without raising your insurance premium. **BY ROY BERENDSOHN**

It seems easy: You want to hang a heavy picture or mount your TV. But behind the smooth wall in front of you could be pipes, ductwork, or electrical wiring. If you cut without a plan, you can do real damage, both to your home and your wallet. Here's how to avoid major problems.

STEP 1

DETERMINE YOUR SURFACE.

Most houses will have drywall, but many built before 1950 used lath and plaster, which is harder than drywall, brittle, and much thicker. You can feel the difference, but if you're still not sure, a pushpin will go into drywall. It won't go into plaster.

STEP 2

FIND THE STUDS.

Whether you're hanging a kitchen cabinet or a coat hook, your best option is to attach things to a stud. If you're working with plaster, this can be tough, since the fasteners used to attach the lath will throw off a stud finder. One way to cheat is to look for a light switch. Most are mounted inside the first stud by the door frame. (The box holding its wiring needs to be attached to something sturdy.) Take off the switch plate and you can see which side of the stud

the box is mounted on by spotting the screws. Most wall framings set studs every 16 inches, so you should be okay to measure from there, but double-check with a pilot hole. You need to drill through the plaster and into the wood framing. Expect your bit to take a beating from the harder material. While most drywall is $\frac{3}{8}$ or $\frac{1}{2}$ inch thick—and thus works with $1\frac{1}{4}$ -inch screws for light loads—plaster can range from $\frac{3}{4}$ inch to $1\frac{1}{4}$ inches thick, so you may need screws up to $2\frac{1}{2}$ inches long.

STEP 2

CONT'D.

If you're working with drywall, you have a few more options:

- Scan the wall with a stud finder. These devices detect either the edge of the stud or its center.
- Use the back of your knuckle and rap horizontally along the wall at 1-inch

intervals. The noise should go from hollow to solid when you get to the stud.

- Run a powerful rare-earth magnet along the wall. It will stick where a screw or nail is driven. This is also a good way to find metal studs, used in many apartment and commercial

buildings and not easily located by a stud finder. If you're hanging anything of significant weight (over 10 pounds), reinforce it with a section of 2 x 4 to spread out the weight along the stud and keep the metal from twisting.

STEP 3

CHECK FOR AIR DUCTS, PIPES, AND WIRES.

The easiest option is to use a professional-duty stud sensor, which often has settings to detect energized wires and buried pipes. If you're finding a lot of wires, cut power at the service panel before drilling holes or doing any disruptive work. When boring between studs, drill a hole through the drywall, stop the moment it breaks through, and poke a pencil or other probe into the hole before proceeding. You can also get an approximate idea where pipes and wires are by looking in the attic and basement to see where they run up or down through the framing.

If you have a lot of wall fastening to do in an old house or in walls crowded with pipes and wires, consider buying a cordless inspection camera such as the **DeWalt DET410S1** (\$267). It lets you see inside wall cavities, and its wireless screen can be removed, allowing better visibility in a tight spot or odd location, such as the back of a closet.



SITUATIONS YOU MIGHT ENCOUNTER IN YOUR WALL



✗ After drilling through a layer of plaster, you can't push the drill any farther.

The plaster might be over brick. If you see dark powder on the end of your drill bit, switch to a masonry bit and a masonry-screw anchor.



✗ You locate a stud with a stud finder, but when you go to drill, you hit multiple layers of drywall.

In shared walls of apartment complexes, townhouses, and condominiums, some builders use double layers of drywall for soundproofing. You'll need longer screws.



✗ You hear an angry buzzing when you cut into the drywall.

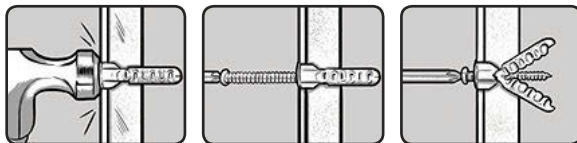
You hit a beehive between the studs. The bees will soon come through the hole and probably be not too pleased with you. This actually happened to someone we know.

STEP 5

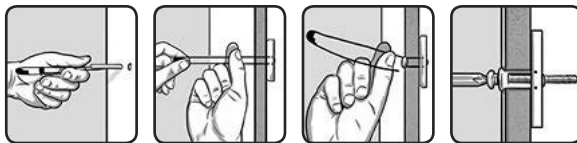
... OR USE AN ANCHOR.

Regardless of the type of surface you encounter, sometimes the easier and better solution is not to worry about attaching to a stud but to use a hollow wall anchor. Mechanical Plastics Corporation makes three great options.

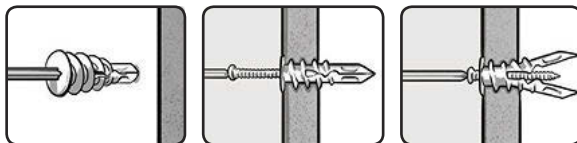
➔ **THE ALLIGATOR** works in solid concrete, concrete block, hollow brick, drywall, tile over drywall, and plaster. You drill a hole the same size as the anchor, tap it in, and drive the screw into it. The anchor expands up to two times its length to fill the hole, or, if it hits open space, it spreads up and down like an open alligator jaw to hold to the back of the surface.



➔ **SNAPTOGGLES** are incredibly strong. They'll hold up to 356 pounds in $\frac{5}{8}$ -inch drywall or plaster. You drill a hole in the wall, insert the toggle, then pull it tight against the back surface of the wall. After sliding the cap all the way to the surface, snap off the excess straps protruding from the wall and drive the screw.



➔ **SNAPSKRUS** are simple to use and strong. They're self-screwing. After mounting them in the wall, drive your screw.



STEP 4

FASTEN TO THE STUD...

Use screws, not nails, since screws can always be backed out with minimal damage if you hit an obstruction. Nails can go right through, and then you might further damage the wall surface when you pull them out. Instead of drywall screws, use self-drilling screws with a large, flat washer head and coarse threads that are meant to bite into softwood lumber. They're easier to drive, and the flat head acts like a clamp, evenly distributing force as the screw is driven. It works better than the bugle-shaped head of a drywall screw.

Never use a screw longer than is absolutely necessary, in order to avoid hitting buried pipes and wires. For most drywall jobs, that means $1\frac{1}{4}$ inches. This size is much stronger than you think. Some can withstand thousands of pounds of force.

STEP 6

IF YOU HIT SOMETHING.

Stop. Never push through, assuming that you're breaking through flashing or a knot in the wood. There's a good chance that you're about to pierce some ductwork or ruin your drill bit against a metal protector plate over a pipe or cable. Back it up and try another spot. This is no time for the use of force.



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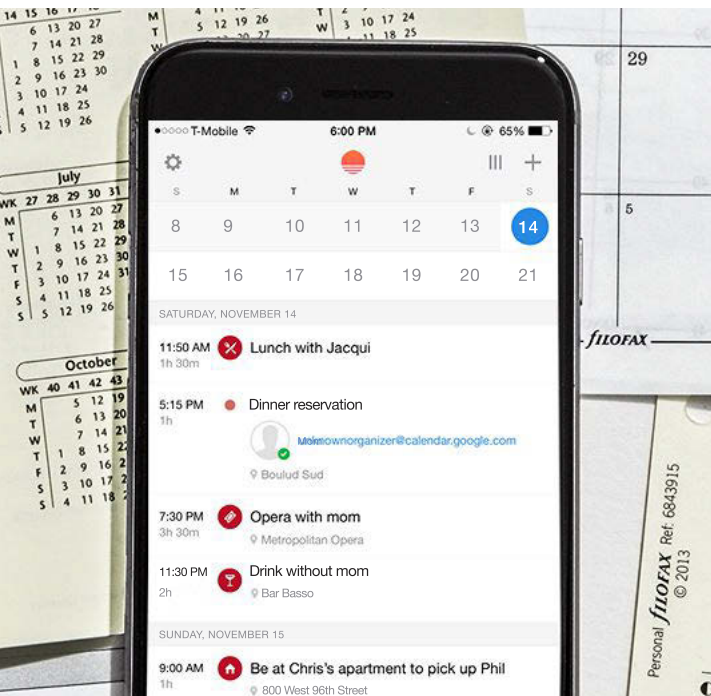


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ONE SATURDAY, FOUR APPS

A technology addict attempts to make the iPhone a tool again, instead of a distraction. **BY ALEXANDER GEORGE**

Waking up on a Saturday, without lifting my head, I reach for my phone, holding it sideways while I check Instagram, then Snapchat. Then I'm looking for a new *Star Wars* trailer. Then I'm reading the entire Wikipedia page for *The Fast and the Furious*.

An hour later I'm still in bed. The apps are so attention-grabbing I can't extricate myself. Is there an app I could use to solve my app problem? Earlier that week I had asked high-functioning friends exactly that question, and downloaded a few candidates: **Sunrise** promised to aggregate events from iCal, Google Calendar, Reminders, and Outlook, so I wouldn't miss appointments scattered all over my phone. **Hooks** controlled notification overload, so I'd get a buzz only for things I cared about. **Launcher** created rows of custom one-touch shortcuts. **Pocket** stored articles so I could read them later.

Still in bed, I received a text inviting me to hit golf balls the next day. I hit the ADD button on Sunrise, and by the time I had typed in "chelsea pi," it found the local driving range, Chelsea Piers, and created the event. Above that the app showed the OpenTable reservation my mom had sent me for dinner. It was scheduled to start in seven

hours. So far, the apps were working: I got out of bed.

Saturday afternoons I reserve for light cleaning, a chore that should take minutes, but takes me hours: I pick up a pair of socks, check Twitter. Put a book on the shelf, research songs on Tidal. This time I'd turned off my regular notifications and set Hooks to ping me only if there was a forecast for rain or if Elon Musk tweeted—essential news, for me. Phone silent, I managed to clean a toddler-size stack of dirty dishes. Success!

Sunrise sent me a notice an hour before dinner. I tapped the location field, which opened Google Maps directions to the Italian joint where I was meeting my mom. When we were done, I got home with the tap of a button as well. I had preset Launcher to open Google Maps and give me directions from my current GPS location to my apartment. After saying goodbye, I hit the icon and was en route. It saved maybe

three taps, but that was enough to prevent me from clicking on Twitter and losing half an hour.

The subway home, I thought, would be a perfect time to use Pocket, to which I'd saved a few articles during the week. As long as you remember to sync it, Pocket will store almost any page so you can read it without a signal. Unfortunately, it didn't do much for my focus. I got five paragraphs into a *New Yorker* feature, started reading a guide to doing handstands, then finally regressed to a Spotify playlist. I was learning a hard truth about brains and phones: An app needs to be practically foolproof to overcome the chimes and tweets and listicles clamoring for attention. I believe Sunrise will benefit everyone who tries it, as will Hooks, as long as you carefully audit your existing notifications. Pocket and Launcher, on the other hand, are like healthy vegetables you buy at the supermarket. You might eat them, but they might also sit on the shelf until they rot. Better not to download them in the first place, to preserve the myth that it's the phone, and not you, that keeps you unfocused.



The Curious Idiot HOW TO PAIR BLUETOOTH

Associate editor **Kevin Dupzyk** is good at many things. Basic technology, however, eludes him.

Using a Bluetooth device always felt like a close encounter: futuristic technology, flashing lights, strange sounds. The logo even looks like it's from *Space Invaders*. But then I sat down with our tech editor, Alex George. Once I learned how to go into the phone's settings, make sure Bluetooth is turned on (the invader shows up), and hit the pairing button on the thing I'm trying to connect, things got... easier. Sometimes you press the pairing button, and sometimes you have to hold it for a few seconds. You'll know if a new noise or light shows up. Yet another sound means the speaker is paired. I was disappointed to find out that the sound is different on every device. Even more to discover that Bluetooth is monogamous: If someone connects after I do, I have to re-pair the next time I want to use my speaker. Annoying, yes, but no longer insurmountable.

THE APPS WILL SAVE YOU

PROBLEM

SOLUTION

So many things to do!



• Sunrise aggregates all of your appointments, plans, and favorite TV shows.

So many tweets!



• Hooks gives you only the alerts you care about.

So much to read!

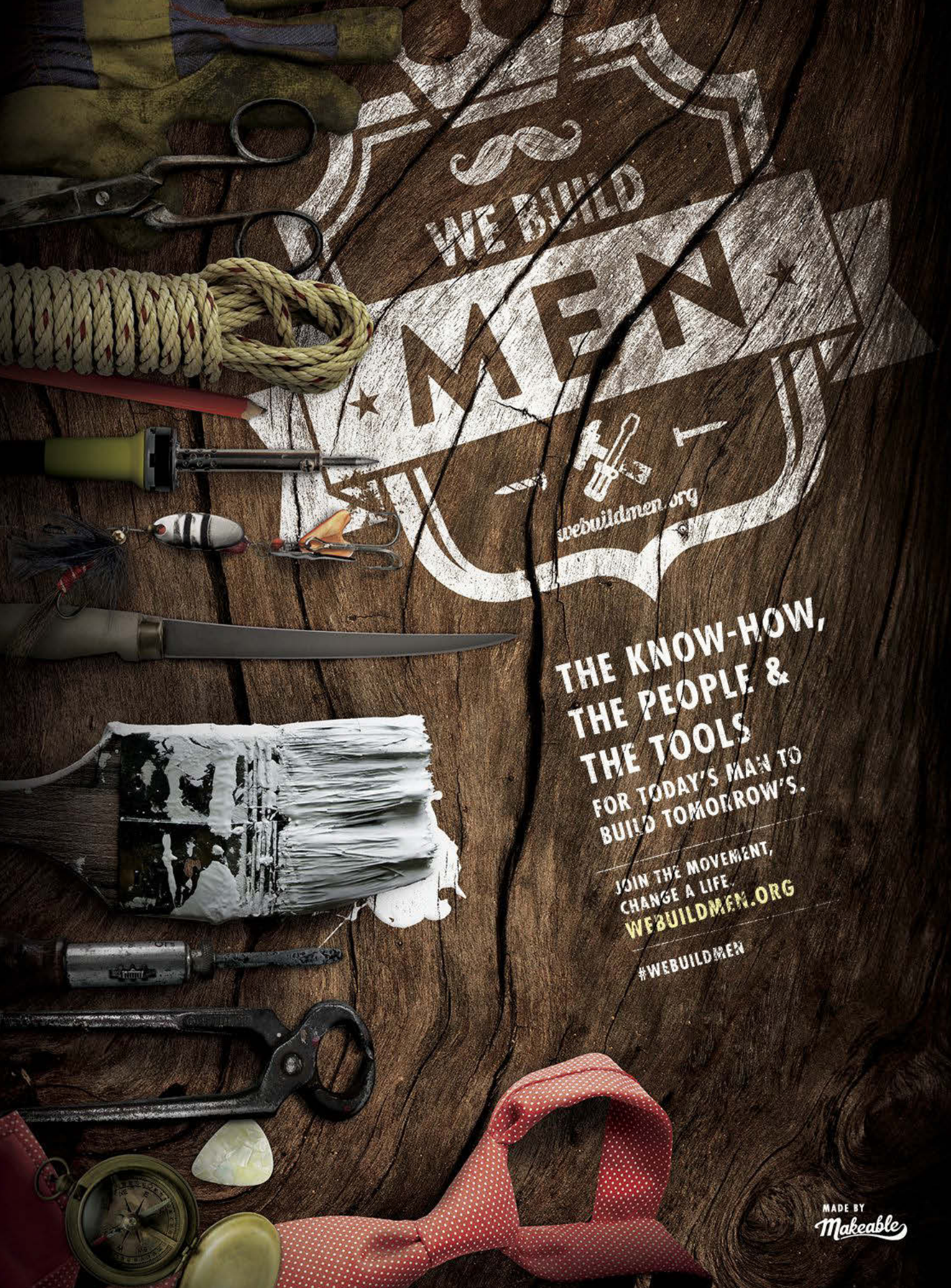


• Pocket saves articles to read later, even offline.

So many buttons!



• Launcher helps you build shortcuts.



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DISASSEMBLY REPORT

PAY PHONE

MODEL: PROTEL XP1230

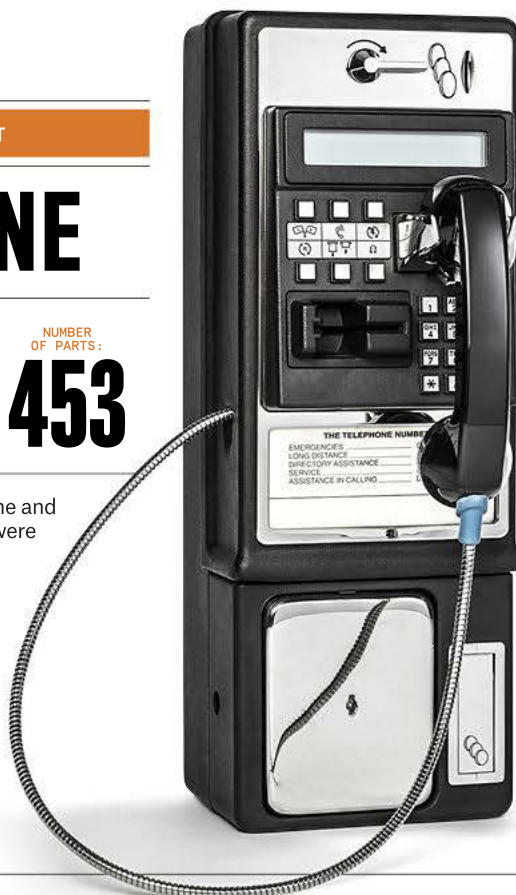
PRODUCED: LAKELAND, FLORIDA

TIME TO DISASSEMBLE: 4 HOURS, 45 MINUTES

NUMBER OF PARTS:

453

NOTES: For years, if you were away from home and wanted to make a phone call, pay phones were your only option. Even now that most of us have phones in our pockets, pay phones aren't going anywhere. The FCC suggests having them in certain places for the sake of public safety or welfare (such as outside a police station, where you might need to make a call after being arrested). Pay phones manage to connect calls, set prices, and accurately collect payment using only electricity drawn from the phone line. They're also basically bullet-proof, devised to withstand all manner of vandalism and theft.



POWER

In the 1980s, the telephone companies that owned the nation's phone lines required that phones draw power only while in use. When the **hand-set (22)** is removed from the **cradle (23)**, the lever releases and triggers the **hook switch (21)**. That allows the phone to start drawing power, giving the user a dial tone—the signal that the phone is ready to be used. During a call, the 48 volts of electricity supplied by the phone lines power all the phone's electronics, including, crucially, its **master controller (3)** and **LCD screen (1)**. The phone has a rechargeable **NiCd battery (2)** used for only one purpose: When the handset is replaced in the cradle, the phone has to either bank the payment for the call or return coins to the caller. Each call charges the battery just enough to carry out this operation.

PAYMENT

The XP1230 offers two ways to pay: card or coin. At the time this phone was designed, calling cards were used more often than credit cards. The **card reader (27)** built into the phone's **upper-housing faceplate (26)** accepts either. Coin payments are more complicated. When an object drops through the coin slot in the **chrome faceplate (24)**, it falls into the **enclosure (6)** of the **electronic coin mechanism (4)**. As it falls, it passes by two pairs of wire **coils (5)** and iron disks. One pair emits a high-frequency alternating current, which measures the coin's surface characteristics—for example, a stamping of Washington or Jefferson. The second pair emits a low-frequency current that penetrates the object and reveals what it's made of. Combine the two and you've got a good way to

distinguish a quarter from a poker chip. Assuming it's a coin, the payment proceeds into the **escrow relay (9)**. If the call isn't completed, a **coil (8)** powered by the battery tips the relay to the right, sending the coins down the **coin chute (11)** and into the refund gate. If money is owed, the relay tips to the left, and the coins fall into the **coin box (17)**.

SECURITY

The XP1230 has a number of features designed to keep it intact. The coin box, with a capacity of up to \$195, is a target for theft. It fits into a hole in the phone's **lower housing (25)**, where the **coin-box spring (19)** holds it tightly in position behind the **vault door (16)**. Two mechanisms must be unlocked to remove it. One is built into the **coin-box lid (18)**, and the other is a four-armed **locking mechanism (15)** behind the vault door. Until turned by a **T-key (14)**, the arms fit into slots in the body of the phone, keeping the door shut.

Coins can also be pilfered through the **refund gate (13)**. Vandals used to jam a sock inside the coin return in the morning, then go back in the evening, pull the sock out, and collect the coins that had gotten stuck above it. To prevent this, the **coin-refund door (10)** is rigged to block access to the coin chute when the door is opened.

The other major target for theft is the handset. To prevent cutting, the **lanyard (20)** that connects it to the phone has steel braided sheathing on the outside and a heavy-gauge stainless-steel wire down the center. The **lanyard anchor (12)** keeps it securely fastened to the **upper housing (7)**. Unfortunately, there's nothing to keep it sterile. —KEVIN DUPZYK

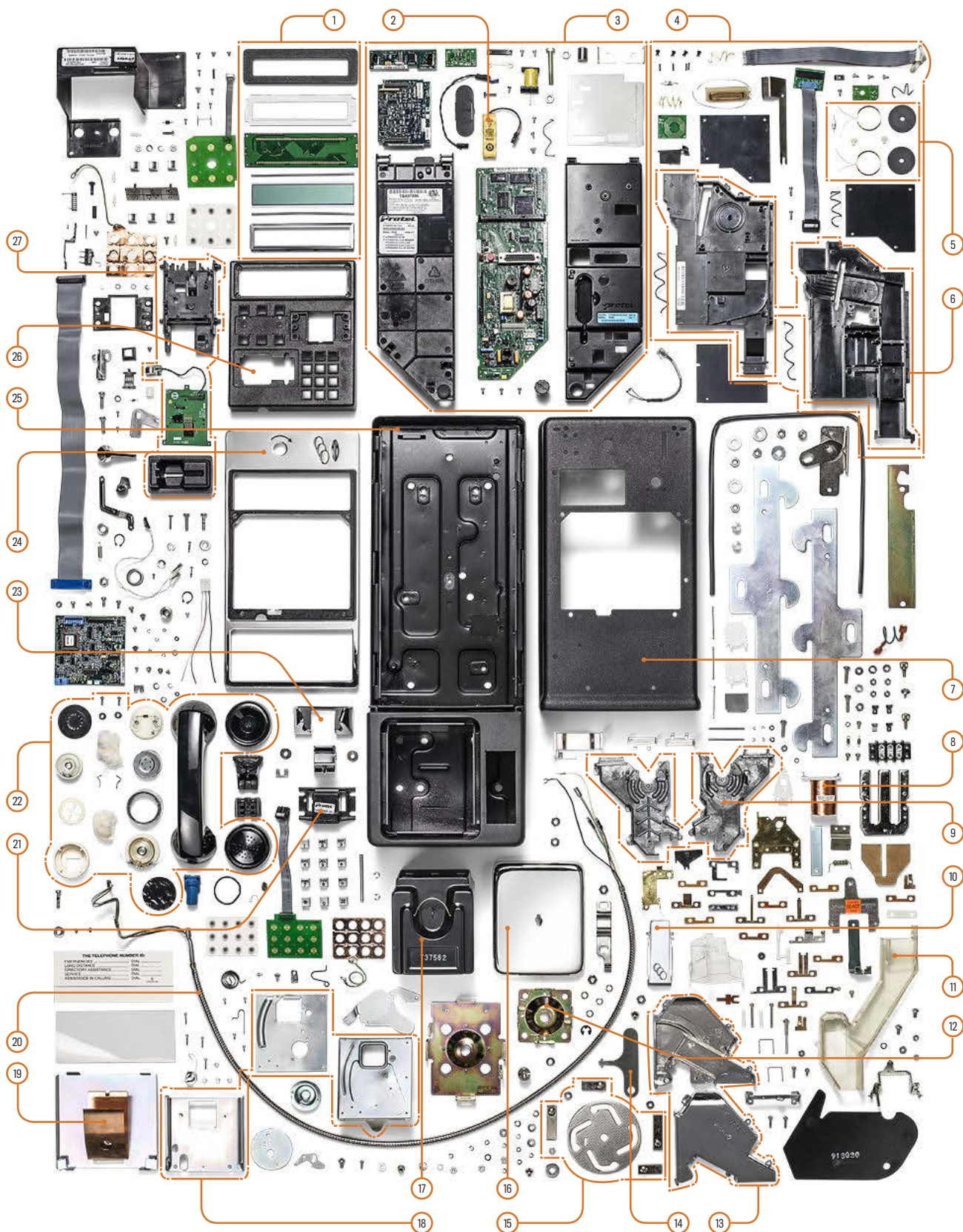
REASONS YOU MIGHT FIND YOURSELF IN NEED OF A PAY PHONE

- Your cellphone died.
- You are in a sub-way station.
- You are a fan of prank calls and don't know how to turn off your caller ID.
- You miss the good clean fun of the 1950s.
- You need change and are hugely optimistic.
- You are having an affair.
- A crime is being



committed and you're still in your civilian clothes.

- You don't have pink eye and are interested in catching it.



RESPECT THE TURKEY

How not to embarrass yourself at the holiday table. **BY WYLIE DUFRESNE**

If you take a close look at Norman Rockwell's iconic painting of a family gathered around their holiday dinner, you'll notice that the grandpa, in a matter of seconds, is going to pick up the carving knife and hack the bird apart right at the table. Now, maybe he happens to have great knife skills and he will not, in fact, dishonor the meat before everyone's very eyes. But that is unlikely, because most people don't know how to properly carve a turkey. What the man should do is tell his wife to hand him the bird so he can take it back to the kitchen, put it on a cutting board, and carve it slowly and properly, without the entire family looking on.

I've been the designated turkey carver in my family for years. Somehow I've managed to get away with

doing very little cooking during the holidays, but everyone assumes I'm going to take care of two important tasks: pulling corks out of wine bottles and carving. I enjoy both jobs, and I find the carving almost therapeutic. While the whole family is busy gathering around the table, figuring out where to sit and whose wineglass is whose, I get to escape to the kitchen and spend a few quiet moments with the bird. I can't overstate the importance of careful carving: Someone (ideally not you) has spent days planning and preparing the meal, and hours watching over the meat in the oven. The last thing you want to do is mess it up at the end. You owe it to everyone to understand the anatomy of the animal and remove the meat in the proper way. Start by letting the meat rest for up to 45 minutes. Then do this.

THE TOOLS

All you really need for this task is a knife and a fork. I've used all types, depending on what I'm able to find in other people's drawers, but these are best:



▶ The curve of a traditional fork can get in the way. The **F. Dick 7-inch straight-tined fork (A)** is flat, which means that when slicing you can run your knife straight down the back of the fork and into the meat.

▶ The **Honesuki-style boning knife (B)**, usually 5.75 inches long, is designed for butchering poultry. A suitable (and easier to find) alternative: the **Wüsthof Classic 6-inch boning knife (C)**.

Go to popularmechanics.com/turkey for the definitive VIDEO of how to carve a turkey.

HOW TO CARVE A BIRD



1 With the bird on a cutting board inside a sheet pan, make an incision between the body and the drumstick.



2 Once you've cut through skin and meat, use a hand and your knife to crack the thigh joint.



3 Separate drumstick and thigh by working your knife into the apex of the V formed by the leg and pulling.



4 To remove the thigh bone, slice along it until you can see the end, then pull up on the end while scraping the bone with the knife. Slice the meat.



5 Remove the wing the same way you separated the drumstick and thigh. Pull the wing out until you see the joint and run your knife through.



6 To remove each breast, slice along the rib cage, then downward, pulling the entire breast off as you slice.

A WORK BOOT THAT WEARS LIKE A COFFEE BREAK.



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It's the safety-toe, reimagined. The Wolverine CarbonMAX® safety-toe uses nanotechnology to produce a strong, lightweight and more comfortable boot. The result of years of scientific research, it's one of the first safety-toe boots that feels nothing like a safety-toe, and makes even the toughest work feel lighter all day long. See the new line at wolverine.com/carbonmax.

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CORDLESS DRILL DRIVERS

A situational guide to one of your most useful tools. **BY JOSEPH TRUINI**

At this point, cordless drill drivers are so powerful that they've become hard to test. DeWalt, for example, tumbles its drills in a concrete mixer to ensure durability. Toughness is important, but we wanted to know how well they handled everyday work. We used four of the best new brushless drills—designed without the friction-adding carbon brushes that transfer current from battery to motor in typical drills—to bore 36 holes through a pressure-treated 4 x 4 and drive and reverse 24 lag screws in another. The drills sailed through, even if our elbows did not. While each earned our five-star rating, they're not equally suited to every task. The one for you depends on the type of work you normally do. There are lower budget models out there, sure, and they work fine. But these four are worth the extra investment.



If you are a
woodworker or
furniture maker

★★★★★
BOSCH DDS182-02
\$180

Battery: 4-Ah Li-ion
Motor: 18-v brushless
Speed: 0-500, 0-1,700 rpm
Light weight and small size make this drill easy to handle. It passed all our tests, but we did manage to stall it a couple times boring holes. We liked that its work light, mounted above the battery, was less likely to create shadows than the lights on other drills.

WEIGHT:
4 lb

ICE SCRAPERS

The best options, no matter how far north you live.

★★★★★
OXO GOOD GRIPS
EXTENDABLE
TWISTER SNOW
BRUSH
\$20

This brush is small enough to fit under your seat, yet when fully extended (from 23 to 33 inches) has plenty of length to handle snow and ice on a pickup or van. The scraper is efficient, and the brush head can be set in line with or perpendicular to the handle.



BEST
OVERALL



WEIGHT:
4 lb



WEIGHT:
5 lb



WEIGHT:
5.4 lb

If your woodworking is occasionally interrupted by more intense home construction

★★★★★
DEWALT DCD990M2
\$280

Battery: 4-Ah Li-ion
Motor: 20-v brushless

Speed: 0-450, 0-1,300, 0-2,000 rpm

The most responsive trigger of the four. Also has great comfort and balance that allow you to make the most of its impressive power. Its three speed limits are extremely helpful in driving. By limiting the motor speed, you're not as likely to snap off or overdrive fasteners if you don't have the clutch set exactly right.

If you are a plumber or an electrician

★★★★★
MILWAUKEE 2703-22
\$280

Battery: 5-Ah Li-ion
Motor: 18-v brushless
Speed: 0-550, 0-2,000 rpm
At 1,200 inch-pounds of torque, the Milwaukee is the most powerful drill we tested (110 inch-pounds more than the next highest, the Makita). It cruised through the tests. It has a stout drivetrain, which helps you drill big holes and drive lags with ease.

If you are a commercial contractor who often does concrete fastening

★★★★★
MAKITA XPH07M
\$300

Battery: 5-Ah Li-ion
Motor: 18-v brushless
Speed: 0-550, 0-2,100 rpm
Makita builds this tool only as a hammer drill, which tells you something about its performance. It is meant for drilling and driving everything from wood to steel to concrete. At 2,100 rpm it's the fastest of the tested drills but doesn't sacrifice control or smoothness.



★★★★★
**TRUE TEMPER TELESCOPING
SCRATCH FREE SNOW BRUSH**
\$25

If you have a truck or a van (or even a big rig), this brush, with its 52-inch telescoping arm, can handle it. Instead of bristles, the True Temper uses a soft foam head that pushes snow away without damaging your paint, glass, or mirrors.



★★★★★
**HOPKINS SUBZERO
10-INCH ICE CHISEL SCRAPER**
\$3.50

A comfortable upgrade on the classic, the Hopkins scraper has a cushioned handle and a two-channel scoop that looks more like a snow plow than an ice scraper and helps disperse the snow and ice as you work. Best of all, it's cheap, durable, and fits in your glove box.



LIQUID RUST REMOVER

For those times when you don't feel like spending two hours scrubbing with sandpaper. So, always. **BY JAMES SCHADEWALD**



★★★★★ 1. EVAPO-RUST

\$23 for 1 gallon

Effective and quick. After six hours of soaking, the test blank was quite clean. After 12 hours, it was spotless, including the corners and the weld. We noticed some carbon deposits had leached out of the steel, but with a little effort we managed to wipe these off.

BEST SOAK



★★★★★

2. BULL FROG RUST REMOVER

\$11 for 16 ounces

Its thick, honey-like consistency provides good vertical cling and required very little scrubbing to remove rust. The Bull Frog stayed moist and effective, even after being exposed to air for two hours. It was also the only product we tested that prevented flash rusting (which can happen within 20 minutes of treatment if you don't prime or seal quickly) by using a Vapor Corrosion Inhibitor that bonds electrochemically with the freshly cleaned surface.

BEST BRUSH-ON



★★★★★

3. WORKSHOP HERO METAL RESCUE

\$25 for 1 gallon

Six hours in the Metal Rescue bath will get your part clean enough to finish the job with hand tools. Leave it in for 24 hours, though, and it's impeccable. Worth the wait.



★★★★★

4. UNRUST RUST REMOVER

\$20 for 16 ounces

Dissolve a lot or a little of this crystallized product in water, depending on the job. Brush-on application was moderately effective, and soaking produced better results if you waited a full day. Unlike other options, you can apply this with a garden sprayer to vertical concrete or plastic that's been stained by irrigation water.



NASA'S RUST FACTORY



Our 4 x 6-inch test samples were uniformly pre-rusted in a seawater-exposure rack by NASA's Corrosion Technology Laboratory at the Kennedy Space Center. Each steel sample has a piece of C-channel welded to it, which allowed us to test the rust removers on a flat surface, an inside and outside corner, and a weld.



THE PHANTOM ROSE GOLD

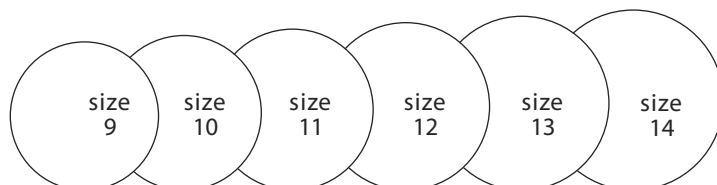
'PHANTASTIC VALUE PHENOMENAL QUALITY'

Phantom Watch \$199 Phantom Ring \$129 Set Price \$289 (Save An Extra \$39) + S&P

The Daniel Steiger Phantom Rose Gold. Engineered from premium grade 316L steel and plated in a mixture of rose gold and black IP, the words designer styling really could have been invented for this timepiece. A precision chronograph movement featuring 24 Hour, Stopwatch Seconds & Minutes sub-dials and date window are displayed on the multi-levelled face. Now available direct from the manufacturer at the astonishingly low price of \$199 - a saving of \$596 on the retail price of \$795. So how can we make an offer like this? The answer is beautifully simple. We have no middleman to pay, no retail overheads to pay and not the usual mark-up to make, which on luxury items can be enormous. To accompany the Phantom, we have introduced the Phantom ring. With layers of rose gold plated steel and an impressive row set with our flawless Diamondeau gems, that can cut glass like a mined Diamond.

RING SIZE CHART: Place one of your own rings on top of one of the circles to the right. Your ring size is the circle that matches the diameter of the inside of your ring. If your ring falls between sizes, order the next larger size.

SPECIFICATIONS: Premium grade 316L stainless steel, Two-tone rose gold and IP black finish, Precision chronograph movement, 5 year unlimited movement warranty Magnificent presentation case



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Popular Mechanics' senior home editor solves your most pressing problems.

BY ROY BERENDSOHN



In 12 years we've lost three mailboxes and one post to snowplows. Is there any option that can take a hit? ALICE B., MANCHESTER, NEW HAMPSHIRE

A Your simplest choice is to shield the box by leaning a piece of plywood against it. Stake it in place and brace it with construction lumber. Although these shields can get slammed and ruined along with the box, most hold up okay. The second idea is to let the mailbox move with impact. That's why you see mailboxes dangling from chains. But if they aren't robustly designed, they can get ripped off. A better solution is the Mail-Swing, a 40-year-old design in which the mailbox post has a socketed, free-swinging arm. Both the post and the arm are built from galvanized-steel pipe. When struck, the arm absorbs the impact and swings a full 360 degrees. The mailbox is bolted to the arm with U-bolts, and

as long as those bolts are secure it can withstand severe abuse. You can also look into the cottage industry that has developed to build truly severe-duty mailboxes and posts. Fortknoxmailbox.com sells boxes built from ¼-inch steel plate. Its Senator model weighs 148 pounds—and costs \$500. Or you can build your own post. (See right.) Regardless of the solution you choose, if you're putting in a new mailbox and post, call 811 before you dig to locate underground utilities.

Q An electrical outlet in our basement has a darkened face and a faint black line above it. I've never plugged anything in there. What could be causing this?

JERRY R., GOSHEN, CONNECTICUT

A Have an electrician look at the outlet. He will cut power to the circuit and remove the device. If overheating is the culprit, the electrician will look at the wiring to the outlet and how it was connected to the device. While it's possible that the outlet was badly installed, it's also possible that it was correctly installed and that there was a onetime event such as an over-voltage from a lightning strike. Known as a transient surge because it lasts only a fraction of a second, this can damage the outlet, its wiring, and perhaps even the circuit breaker. The electrician will look for telltale signs of this,

such as melted plastic or copper. Even if the electrician removes the outlet and doesn't find anything amiss, I'd still replace it. If it somehow got so dirty that the face is darkened, there's probably also dirt inside on the contacts.

Q There's a big oak tree in my yard that I'm going to have removed. I want to turn its trunk into lumber for a wood-working project. What do I do with the logs after the tree is cut down?

NOAH N., HOUSTON

A The first challenge will be finding a sawmill willing to saw the tree into planks for you. Many will not bother with this kind of wood. Yard trees, as they're called, can be loaded with hardware: old eye screws from a hammock, spikes from a tree fort, barbed wire. If you do find a mill, as soon as the tree is cut, coat the ends of the logs with latex paint to trap moisture. Rapid moisture loss can lead to severe cracks, making the wood unsuitable for lumber.

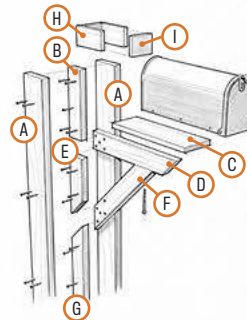
After the wood is sawed, stack it neatly off the ground in a dry location. Each plank needs a wood strip, called a sticker, between it and its neighbor. Stickers should be spaced 24 inches apart and arranged vertically over one another.



Call 212-649-2828 and leave a message with your home or yard question. You could be featured on a new Popular Mechanics podcast. Questions can also be emailed to askroy@popularmechanics.com.

THE PLOW-PROOF MAILBOX

Designed by Mark Clement



- A:** 2" x 6" x 80"
- B:** 2" x 4" x 16"
- C:** 2" x 6" x 16¾"
- D:** 2" x 4" x 22¼"
- E:** 2" x 4" x 10¾"
- F:** 2" x 4" x 23½"
- G:** 2" x 4" x 48¾"
- H:** 1" x 4" x 7"
- I:** 1" x 4" x 6"

Dimensions for angled pieces D, E, F, G are for the longer side.

SHOPPING LIST

- 3 2" x 6" x 8', pressure treated
- 1 2" x 4" x 8', pressure treated
- 1 1" x 4" x 8', pressure treated
- 1 box No. 10 2" screws, rated for pressure-treated lumber
- 1 4" hot-dipped galvanized structural wood screw

► **Crosscut the two** outer 2 x 6 parts (A) to length. Do the same for the crossarm (D), box-support shelf (C), and the crossarm brace (F). Attach C to D and screw the assembly to the 2 x 6 (A). Attach the brace (F) to the 2 x 6 (A). Drive the structural screw from the brace (F) into the crossarm (D).

► **Crosscut parts B, E, and G** and fasten them to A. Attach the second 2 x 6 (A) by driving screws through it and into the part below. This completes the I-beam structure.

► **Crosscut the cap** parts (H and I) and screw through them into the outer 2 x 6s.



I AM NOT A RUG

As few as 3,200 wild tigers remain. Poaching for their skins, bones and other parts is the greatest immediate threat to their survival.

Find out what you can do to stop wildlife crime.



worldwildlife.org/wildlifecrime

Meet the Beauty in the Beast

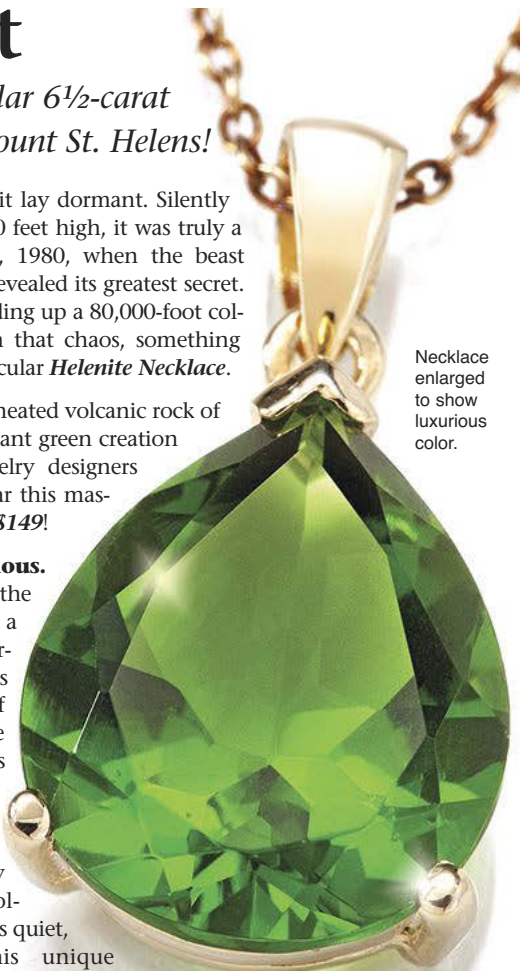
Discover this spectacular 6½-carat green treasure from Mount St. Helens!

For almost a hundred years it lay dormant. Silently building strength. At 10,000 feet high, it was truly a sleeping giant. Until May 18, 1980, when the beast awoke with violent force and revealed its greatest secret. Mount St. Helens erupted, sending up a 80,000-foot column of ash and smoke. From that chaos, something beautiful emerged... our spectacular *Helenite Necklace*.

Helenite is produced from the heated volcanic rock of Mount St. Helens and the brilliant green creation has captured the eye of jewelry designers worldwide. Today you can wear this massive 6½-carat stunner for **only \$149!**

Make your emeralds jealous.

Our *Helenite Necklace* puts the green stone center stage, with a faceted pear-cut set in .925 sterling silver finished in luxurious gold. The explosive origins of the stone are echoed in the flashes of light that radiate as the piece swings gracefully from its 18" luxurious gold-finished sterling silver chain.



Necklace enlarged to show luxurious color.

EXCLUSIVE FREE

Helenite Earrings
-a \$129 value-
with purchase of
Helenite Necklace



Today the volcano sits quiet, but this unique piece of American natural history continues to erupt with gorgeous green fire.

Your satisfaction is guaranteed. Bring home the *Helenite Necklace* and see for yourself. If you are not completely blown away by the rare beauty of this exceptional stone, simply return the necklace within 30 days for a full refund of your purchase price.

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- J. from Orlando, FL
Stauer Client

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- 6 ½ ctw Helenite in gold-finished sterling silver setting - 18" gold-finished sterling silver chain

Limited to the first 2200 orders from this ad only

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Helenite Stud Earrings (1 ctw)**\$129** +S&P

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ASTRONOMY

Giant balls of plasma held together by gravity, spinning galaxies so far away we don't know if they exist anymore, cosmic dust borne from supernova explosions—space is awesome. To appreciate it, all you have to do is look up.

On September 27, a rare total lunar eclipse of a super moon, called a blood moon, caused a sensation—and mass Instagramming—around the world.



Choose Your Telescope

IT'S TRUE: You can do a lot of stargazing with a good pair of binoculars. But if you really want to get into astronomy, you need a telescope. And to that end, nothing can—and will—spoil your first foray faster than a bad scope. So don't settle for anything suspiciously cheap, and make sure you understand the basics.

Aperture

The hole through which light passes, usually the diameter of the main lens or mirror. The larger the aperture, the better the resolution. For beginners, a 6- to 8-inch aperture is optimal. "Really, today, with the light pollution, you almost need to go eight," says Roger Kolman, a 55-year amateur astronomer and second vice president of the American Association of Variable Star Observers.

focal length (say, 1,400 mm) is better for viewing closer objects, such as the moon and planets. For deep-sky galaxies and nebulae, a shorter focal length (sub-1,000 mm) is ideal. "Remember, the smaller the field of view, the harder it is to find things," Kolman says.

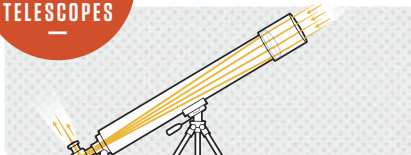
Magnification

Cheap telescope manufacturers are always touting magnification power on the box, but that's misleading—just making something bigger isn't helpful if the resolution is poor. Magnification is simply a measurement of the telescope's focal length divided by the focal length of an attached eyepiece.

Focal length

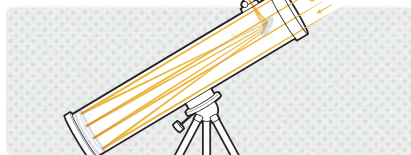
This is the distance a lens or mirror bends gathered light to a focus point. The larger the focal length, the smaller the field of view. So a telescope with a high

PRIMER: TYPES OF TELESCOPES



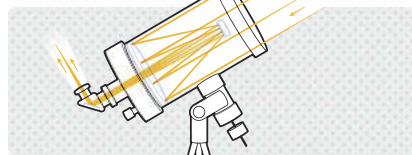
↑ Refractor

Your classic long and skinny telescope. Refractors bend incoming light through one curved lens into another curved lens just before the eyepiece. This simple setup makes refractors durable and low maintenance, but the high-quality lenses also make them an expensive choice.



↑ Reflector

Great for beginners, reflecting telescopes use a two-mirror system to capture and focus light. They usually have the largest apertures, giving them superb resolution. Reflectors can be big and awkward, but they're the most economical due to a lower cost-per-inch of aperture.



↑ Compound or catadioptric

A stumpy refractor/reflector hybrid that uses a corrective lens and curved mirrors to greatly increase the focal length. Compounds like Schmidt-Cassegrains are more versatile and lighter than reflecting scopes, but their four optical surfaces significantly bump up the cost.



The perfect
starter telescope:

**ORION
SKYQUEST
XT6 CLASSIC
DOBSONIAN
TELESCOPE**

⑦ The XT6 (\$310) is a reflecting scope that delivers high resolution. Its 6-inch aperture and 1,200-mm focal length allow for viewing closer and deep-sky objects, and its Dobsonian ground mount is a more intuitive version of a standard two-axis altazimuth mount. "What's good about the Dobsonian is it's only in two pieces," Ed Ting, creator of ScopeReviews.com, says. "Set the scope into the base, and then off you go."

WHAT ABOUT ...

COMPUTERIZED TELESCOPES?

They're pretty amazing, actually. Although computerized telescopes take some of the challenge out of astronomy, they are definitely handy for beginners. Just punch an object's location into a connected keypad and the scope uses its onboard data-

base and motors to position itself. Remember: "When buying a computer-controlled telescope, you get what you pay for," Ting says. The Celestron NexStar 5SE (\$699) is an excellent scope for a reasonable price.



Upgrade Your Setup

THE ACCOUTREMENTS

Eyepiece ➔

An eyepiece changes the focal ratio of your telescope, thus changing the magnification. Certain eyepieces are better for different viewing situations—say, looking at a whole galaxy versus its individual spirals—so you'll want at least a few extra. The Plössl is a popular style of lens. We particularly like Meade's Super Plössl series of eyepieces, ranging from 6.4 mm to 56 mm (\$32 to \$80 each). When buying eyepieces, opt for a 1.25-inch barrel diameter, which can be used with almost any telescope.



outdated with so many apps available, but a good one is still a necessity. "I would recommend using the monthly charts in either *Sky & Telescope* or *Astronomy*," Kolman says.

Barlow lens

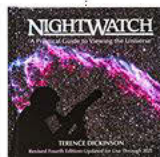
Placed between the eyepiece and the telescope, a Barlow lens essentially doubles the magnification of any eyepiece, making it a staple. The average Barlow is around \$50.

Moon filter

Finding the moon is easy. Seeing it in great detail is a bit trickier—the brightness borders on blinding. Solution: a moon filter. It easily fits on any eyepiece and runs about \$20.

Star chart

A star chart that shows the night sky in 2D may seem



➔ **The book**
NightWatch: A Practical Guide to Viewing the Universe, by Terence Dickinson, is the book you need.

Take it from Alan Dyer, who coauthored another popular amateur astronomy book with Dickinson. "*NightWatch* is the single best guide to getting started in the hobby," Dyer says. "I say that even though I get nothing in royalties."

TWO GREAT (AND FREE) ASTRONOMY APPS



Google Sky Map
Having trouble finding an object? Hold your phone up to the night sky and an arrow will shepherd you through a real-time, geographically accurate map of the stars until you find its location. Available only for Android users.



Celestron SkyPortal
With a searchable database of over 120,000 objects and their positions, SkyPortal offers more entries than Google but without the live functionality. It also includes a history and mythology for more notable objects. Available for Android and iPhone.



**NEIL DEGRASSE
TYSON
WANTS YOU**

The director of the American Museum of Natural History's Hayden Planetarium on the importance of amateur astronomers.

If you are an amateur astronomer, that is a badge of honor, not a badge of denigration. If you were at

a hospital and said, "I got this. I'm an amateur neurosurgeon," they're not going to let you in the operating room. But people will give an amateur astronomer



Get to Know the Night Sky

Learn your constellations and planets

Think of constellations and planets as celestial landmarks—they help you orient yourself when hunting down unfamiliar objects. And the best way to learn them is to just start identifying and memorizing. “The more legwork you put in at the beginning of your stargazing life, the easier things tend to be later on,” Ting says. “Like, oh yeah! That’s Orion, that’s the Big Dipper, that’s Cassiopeia, and now I know my way around.”

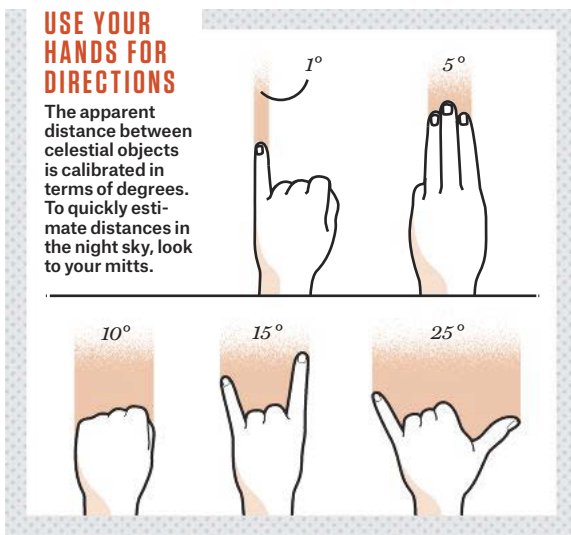
⬇ A quick note about the moon

The best time to view the moon must be when it’s full, right? Nope. The best time is actually when it’s changing from crescent to gibbous, or vice versa. During these transitions, we see sunlight hit the surface of the moon at a lower angle, creating more contrast and showing more surface details than when it is fully illuminated.



the red carpet straight to a telescope, because they know the night sky like the palm of their hand.

Amateur astronomers contribute to the field in huge



When to look for what

- **DUSK AND DAWN:** Because Mercury and Venus are close to the sun and hard to see when it’s high in the sky, these crepuscular conditions are best for viewing.
- **WINTER:** We are looking out to the edge of the Milky Way Galaxy’s disk, so the sky is rich with stars and nebulae.
- **SPRING:** The Earth faces out from the Milky Way, meaning fewer stars and better conditions for spotting distant galaxies.
- **ALL YEAR ROUND:** Look for bright star clusters, such as the Pleiades. As with planets and constellations, clusters help with night-sky navigation.

Join a club

There are hundreds of free amateur astronomy clubs around the country. A meet-up, or stargazing party as they’re often called, is a great place to learn more and maybe even score some cheap equipment. For a list of local events, visit NASA’s Night Sky Network at nightsky.network.org.

TIP!

FILTER YOUR FLASHLIGHT

As anyone who has ever stumbled up a movie aisle knows, it can take awhile for your eyes to adjust to darkness, a process called dark adaptation. To keep your eyes from having to constantly readjust, buy a cheap flashlight with a red filter. Better yet, make your own filter with a rubber band and some red cellophane.



Mark Your Calendar

DECEMBER 4 TO 17:

GEMINIDS METEOR SHOWER

Widely considered to be the best meteor shower of the year, producing up to 120 meteors an hour. It will peak on the night of the 13th and continue into the morning of the 14th. For showers, use binoculars or your naked eye.

FEBRUARY 7:

MERCURY AT ITS FINEST

The closest planet to the sun will be at its farthest point from the star, as viewed from Earth. This is known as elongation—and it’s one of the best times of the year to see Mercury.

MARCH 8:

JUPITER AT OPPOSITION

The closest Jupiter gets to Earth all year. Positioned opposite the sun, it will shine bright. Look for its red and white cloud bands, as well as its larger moons: Io, Europa, Ganymede, and Callisto.

MAY 9:

TRANSIT OF MERCURY

An event that happens only 13 or 14 times a century, Mercury will cross the face of the sun. The next occurrence is in 2019, and then in 2032. Important: If you value your eyesight, use a solar filter.

AUGUST 12 TO 13:

PERSEIDS METEOR SHOWER

The second best shower of the year just after the Geminids. At the Perseids’ peak, you can see about 60 of its famously bright meteors an hour. The best viewing will be after midnight on the morning of the 13th.

ways. In the professional community, we are not looking at all parts of the sky at all times—we can’t. But when you have so many more amateur astronomers in every

time zone of the Earth, this is how you discover things. There are dozens of comets discovered every year, and all of this is fair game for the amateur astronomer.



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NexStar EVOLUTION

The First Schmidt-Cassegrain Telescope with Fully Integrated WiFi

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A BRIEF EXPLANATION

You go chop down a tree, mow the lawn, deep-sea dive, or code at a computer all day, you do it in some kind of apparel. And that apparel, like all of your tools, has to operate in service of the task at hand—like this here neoprene suit in a rescue mission. Be it through the fibers from which they are made, or the ingenious placement of a zipper, or just classic styling, the clothes we wear when we go out in the world are as purposeful and important as what we do when we're wearing them.

01

CLOTHING,
IN
EXTREMIS

THE 1950 STEARNS THERMA SHIELD 24+

Immersion suits—the thick, neoprene numbers donned by sailors forced to abandon ship—are rated to keep a human alive in frigid conditions for at least six hours. By designing the suit so a user's warm breath gets recycled back into the garment and directed toward the extremities, Stearns has found a way to keep a man who's gone overboard safely submerged in 32-degree water for up to 24 hours or more.



02

THE LATEST

Time-tested labels are getting minor updates with the help of their fashion-forward friends.

A. Carhartt WIP

Work in Progress, the Germany-based, fashion-driven spin-off of the classic Detroit work-wear brand, has taken the comfy blanket-lining pattern on the inside of your standard Carhartt jacket and fashioned it into a simple button-down. It's like your hip nephew swiped the work jacket you had hanging in the garage and made it something completely his own. (Blanket Shirt Jac, \$205)

B. Eddie Bauer x Ilaria Urbinati

Eddie Bauer released his iconic quilted Skyliner jacket in 1936. In 2015, the stylist who helps make Bradley Cooper presentable for the red carpet has dipped into Bauer's archive and retooled its iconic Skyliner in a collection of jackets, sweaters, and pants in updated fits and colors for more modern adventures. (Skyliner Jacket, \$250)

C. Cole Haan + Mountain Hardwear Zerøgrand

The city shoemaker and the outdoor performance-gear brand have teamed up to engineer a line of outerwear that combines Mountain Hardwear's technical innovations like water-resistant down insulation and 100 percent waterproof yet breathable fabrics with Cole Haan's street styling. What you get is a wear-to-the-office jacket that could hold its own high in the Rockies. (Commuter Jacket, \$475)

**WHAT I WEAR TO WORK****NICK WICKS MOREAU,
BLACKSMITH**

Woodbridge, Connecticut

Everything you wear when you're working with metal is going to get dirty and lit on fire at some point. I buy Carhartts as my regular pants. Once they get stained, they become my work pants. When you're using an angle grinder, you get a spark flow that hits the right side of your groin along the leg. That's one of the first areas to blow out, so I'll repair it with some patches. Then the patches start to rip, and you repair those. Then the knees will start to go. After six months to a year, the pants will have so much metal dust in them and the patches will have patches, that I move on to the next pair. You take pride in it, all those patches and holes that you earn through the day-to-day of the job. It just means that you're working hard.





Hamilton enlists six shirt cutters, like Robert Kuhn, to cut out each individual pattern by hand.

03

MADE
HERE

THE HAMILTON SHIRT FACTORY

Houston

The headquarters of Hamilton Shirts, makers of some of the most exceedingly well-constructed clothing a man can buy, sits somewhat incongruously on a mish-mash boulevard of auto-glass shops and carpet stores. Somehow, though, it fits.

Hamilton is not a stuffy brand. They will make you any kind of shirt you like, and they will make it right there on that boulevard in Houston. In the front of the space is a well-appointed men's shop: vintage photographs, polished parquet floors. In the back, through a large window like an open kitchen, is the factory, not much larger than an elementary-school classroom, in which trained pattern-cutters and sewers make every shirt that bears the Hamilton name. Also on the premises: David Hamilton, the fourth-generation shirt-maker who sees no reason to move any part of his business out of the country, or even out of Houston. "Having the factory

here allows us to be in it every day," he says. "The breakdown in communication that can happen when you're not there is huge. We do a lot of back-and-forth with our customers, so we need to be making everything right here. We see every adjustment, every measurement."

Hamilton's business is largely custom: You wear your watch on your left hand, so you want the left cuff a tad looser? Breast pocket, for your glasses? Which side? And which of the 500 fabrics would you like, shipped weekly from Italy to this low-slung brick building in Houston? (The company's website lists clothiers in each state who will measure you for a bespoke shirt, or you can take the basic measurements yourself and they'll send you an off-the-rack match.)

The company employs 50 Houstonians, most of them in the factory. The shirts they make? They are worthy of the highest compliment one can pay a shirt: They fit.

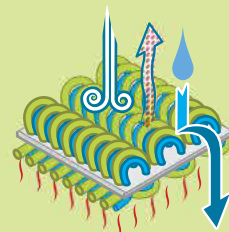
TWO WAYS TO STAY WARM

The latest developments in fending off the cold.



NUDOWN SQUAW PEAK

The idea started with basic chemistry: Fill a jacket with argon gas. Its high molecular density insulates against the cold, and you can deflate the jacket to stay cool. But carrying canisters of a noble gas is a pain. Enter NuDown, which trades argon for free, plentiful air. It's not as effective as argon, but it still retains heat. Squeeze the bulb in the pocket to inflate channels embedded in the wind- and waterproof nylon exterior. Forty pumps keeps you toasty in 20 degrees Fahrenheit.



VOORMI FALL LINE

The traditional way to weatherproof a garment was to sandwich a water-shedding but breathable membrane between the interior and exterior fabrics. It works, but can make your foul-weather softshell feel suffocating. Run by alums from Polartec and Gore-Tex, Voormi takes a similar membrane and weaves it within the knit to create a single-layered fabric instead of three. The process, called Core Construction, gives you a jacket that feels like everyday fleece but repels rain like a duck's back.

Can I Wear This Otherwise?

The work-wear items you'll look good in, even when you're not working.



Coveralls?
YES NO



Work jacket?
YES NO



Red Wing boots?
YES NO



Safety glasses?
YES NO

THE
TRUST
For
Robert's
LAND

*Because we need
more places where
we can dream*



We all need places to get outside—to explore, exercise, and recharge. But with America's open spaces disappearing at a rate of 6,000 acres each day, we're at risk of losing our most cherished outdoor escapes. Together, we can change that. Join The Trust for Public Land to save the lands we all love—from urban parks to vast wilderness. Since 1972, we've worked with communities to protect more than 3 million acres and create more than 5,000 parks and natural places for people to enjoy. Help to keep this land our land.

Share why nature matters to you: tpl.org/ourland | #OurLand

THE
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CARS



MAN VS. DRIVERLESS MACHINE

How smart are so-called smart cars, really? Ezra challenges Audi's self-driving RS7 to a track battle to find out.

Robby cuts the wheel toward the apex of Turn 1, corrects a moment of understeer, and powers out to the edge of the track with tires howling. This is a 560-horsepower machine—an Audi RS7—on Sonoma Raceway, a fast road course scrawled across the hills of Napa wine country in northern California. We're on our way to something like a two-minute lap time, which is seriously hauling butt. Robby really knows this car. Actually, Robby is the car.

Yeah, there's a guy sitting behind the wheel, Audi engineer Markus Hoffmann. But he's not doing anything except holding a kill switch that he'll deploy if he thinks Robby here is about to go *Maximum Overdrive* on us and destroy the

humans. I'm in the passenger seat. Because Robby is loaded down with hardware and electronics that allow him to drive himself, the rest of the car is gutted out, stripped of a backseat and interior trim in the name of weight savings. Audi wants the car and his two passengers to weigh exactly the same as a stock RS7 with only a driver. You see, we're about to have a contest, *mano a máquina*, and Audi isn't about to handicap its robo race car with extra lard. If I outdrive Robby, it'll be on equal terms.

Among the world's automakers, Audi is one of the most heavily committed to autonomous research. In 2010, a modified version of its TT sports car developed with Stanford University raced up Pikes Peak by



itself. Robby's predecessor, Bobby (both were named after the legendary Unser family of racing fame), drove from San Francisco to Las Vegas earlier this year, 550 miles, with the driver just along for the ride. Audi is working on self-parking cars and will soon debut a production system that allows autonomous highway driving in certain situations. But Robby isn't here to prove a car can recognize a stop sign or change lanes to pass a dawdler. Robby is built to demonstrate that Audi's suite of sensors and software is mature enough to take a fast car to its limits on a diabolical road course.

And if it can do that, then there's another layer of confidence when you surrender the wheel on your daily commute. You want to know this thing can drive.

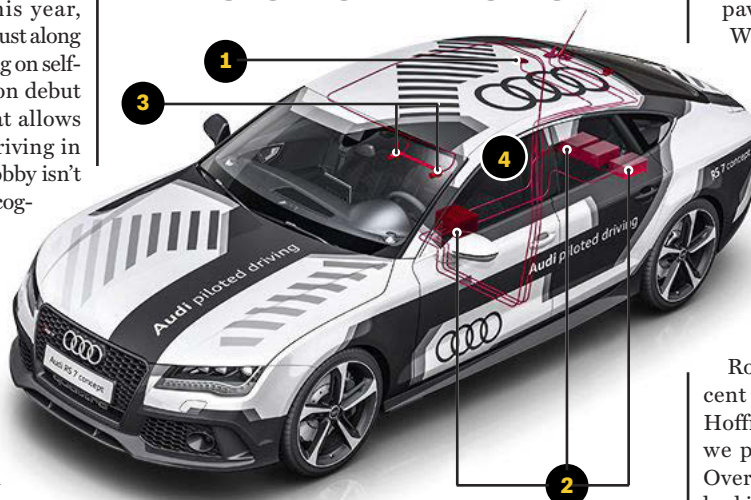
As we make our way around the track, my initial impression is twofold: disbelief that the car is blitzing this track at what feels like 10/10ths, and dismay that I might not be able to match the lap time of this automotive player piano. But as we reach the half-way point of our lap, my sense of sheer sci-fi wonderment gives way to a hint of clinical analysis gleaned from track-day lessons imparted by living, breathing instructors: Robby is fast, but I see how he could be faster.

Where a human driver would try to pick a line and stay on it throughout a corner, the self-steering Audi twitches its wheel with high-frequency corrections, scribbling a sine wave of small inputs. People tend to do that, too, if they're not looking far enough down the track, as short-range focus causes you to drive from point to point instead of thinking about the setup for that corner 200 yards away. If Robby were human, a driving instructor would tell him to keep his eyes up. Camera up, Robby?

Riding with Robby is my first lap of Sonoma, and I'm just trying to note which way the corners go, never mind figure out the braking points and racing line. Ol' Robby's definitely got an advantage when it

THE TECHNOLOGY

HOW AUDI'S DRIVERLESS SPORT SEDAN WORKS



1. Differential GPS: Relies on a new network of fixed ground-transmitter stations that improve the accuracy of roving satellite receivers. Instead of accuracy measured in feet, we're talking inches.

2. Sensor unit, image-processing unit, control unit: The brains of the operation; they process visual and GPS data.

3. Front 3D camera system: The eyes on the road.

4. Driver: Or, as Audi refers to the person behind the wheel, "the final redundant system."

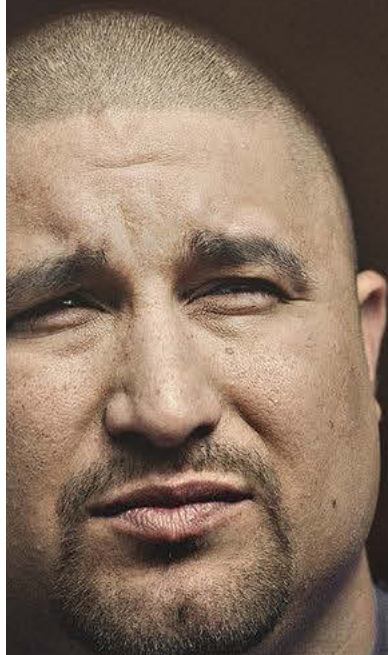
comes to experience. First he took a couple laps and mapped the track with his high-resolution camera, recording the boundaries of the pavement all the way around.

With that data stashed, he overlaid a plot of an ideal racing line and began turning laps. But since each track is different, the theoretical best line is sometimes at odds with real-world technique—maybe you want to sacrifice speed on one corner to set up a blazing exit from the one two turns away. "On his own, Robby can get to about 90 percent of his potential best time," Hoffmann says. "To get the rest, we program it in." Command: Override late apex. Initiate trail braking. Deploy max throttle.

"What happens if a deer runs out in front of us?" I ask as the tach needle bumps the redline and we sail madly over a blind uphill left-hander. "We'd hit it," Hoffmann says. In the name of speed, Robby isn't running radar, because the nature of radar—judging speed to avoid collisions—is at odds with the goal of driving straight toward a wall and hitting the brakes at the last possible moment, as you do before the hairpin at Sonoma's front straight. Robby is fast but



SHANE PARSONS,
WOUNDED VETERAN



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Your watch shouldn't cost more than your car. It should look and feel like a power tool and not a piece of bling. Wearing it shouldn't make you think twice about swinging a hammer or changing a tire. A real man's timepiece needs to be ready for anything. But that's just my opinion. If you agree, maybe you're ready for the *Stauer Centurion Hybrid*. Use your Exclusive Promotional Code below and I'll send it to you today for **ONLY \$59**.

This is a LOT of machine for not a lot of money. The *Stauer Centurion Hybrid* sports a heavy-duty alloy body, chromed and detailed with a rotating bezel that allows you to track direction. The luminous hour and minute hands mean you can keep working into the night. And the dual digital displays give this watch a hybrid ability. The LCD windows displays the time, day and date, includes a stopwatch function, and features a bright green electro-luminescent backlight. We previously offered the *Centurion* for \$199, but with the exclusive promotional code it's yours for **ONLY \$59!**

No matter what, this watch can keep up. Thanks to the Stauer 30-day Money Back Guarantee, you've got time to prove it. If you're not totally satisfied, return it for a full refund of the purchase price. You also get a 2-year replacement guarantee on both movements. But I have a feeling the only problem you'll have is deciding whether to keep the *Stauer Centurion* on your dresser or tucked inside your toolbox.



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— C.S. from Fort Worth, TX

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Rating of A+



COMING SOON

REMOTE-CONTROLLED PARKING



The new 2016 BMW 7 Series has a remote-parking feature intended to help squeeze the car into tight spaces that would otherwise have you climbing out the sunroof. Standing outside the car, you press the forward arrow on the key fob and the 7 Series steers itself into a space. Use the reverse arrow to back it out. Simple, right? Not in the U.S. Here we have a shift-interlock rule that requires the brake pedal to be depressed before you can put a car in gear—difficult to do without a driver in the car. BMW is trying to get some clarity on that regulation, since the rule obviously predates remote-controlled luxury sedans. But they say the system is ready to go as soon as the rules allow.

Racers tell you to drive without emotion, but that's hard to do when the fate of all humankind rests on your lap time.

dumb. Back in the garage, he probably chugs 10W-40 and pays the Stanford TT to do his homework.

When we return to the pits, our lap time is displayed on a whiteboard: 2:02. That's the time to beat, for the honor of humanity. Since I don't know the track, Audi proffers an equalizer: A hotshoe in its R8 supercar will be my lead. I can follow him and try to ape his lines and braking points, if I can keep up.

I try to push it as hard as I can, bearing in mind the peculiarities of the RS7—its torque-vectoring rear differential means you can get on the throttle earlier than you expect, the rear end forcing the front to follow your steering commands. Still, I'm a nervous mess. Racers tell you to drive without emotion, but that's hard to do when the fate of all humankind rests on your lap time. Maybe I'm building this up a little much, but it's hard

not to think about this challenge in absolutes: If the robot car is faster, what's the point in screwing around on tracks? Will anyone care about driving skill if it's relegated to the status of long division? I don't need to know how to do long division. I've got a calculator on my phone.

I pull into the pits to see my time on the whiteboard: 1:59. I beat Robby, albeit with an assist from a fellow sentient being. Victory is ours! My inner ear and I have triumphed over the engineering might of one of the world's biggest car companies. And if a deer had run out, I would've swerved. If only Audi could build a robot as talented as I.

Well, the thing is, they will. Whether it's Robby or the next Unsermobile Version 3.0, they're going to make the steering inputs smoother, the braking zones deeper, the racing line a little closer to the hairy edge of the pavement. The story's not over. Which is underscored as we walk over to the wall at the start-finish line, where Robby's "father," Bobby, sits idling. An unseen engineer pushes a button and the white RS7 roars off for a hot lap. With nobody inside to enjoy it.



⏏ The trunk of Robby's predecessor, Bobby. Audi says that by the time its Piloted Driving system is ready for production, the control hardware (pictured), which currently weighs 20 kilograms, will be about the size of an iPad Mini.

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HOW TO DRIVE LIKE A SECRET AGENT

Without all that bothersome espionage to slow you down.

I'm riding shotgun in a Ford Crown Vic when the driver, Greg Haas, pulls alongside the car in front of us. We're doing about 30 mph. "Excuse me!" Haas calls over to the other driver, "Where is Walmart? You know Walmart? We're looking for values!" Then he abruptly pulls out a pistol and starts firing. His gun isn't real, any more than the bright-red Glock that I'm holding just beneath the window, but damn if the adrenaline doesn't start ripping once I raise my piece and join in the ambush. The driver beside us slams on the brakes and we blow past, our attack foiled. For now.

I'm at the BSR Evasive Driving Course, a two-day school at Summit Point Motorsports Park in West Virginia. This course is open to the public, but everybody here seems to be either a special-forces badass or a chauffeur for the sort of people who have a security detail.

THE DETAILS

- ▶ **WHAT:** BSR Evasive Driving Course
- ▶ **WHERE:** Summit Point, West Virginia
- ▶ **COST:** \$1,695 (two days)
- ▶ **FOR ARRANGEMENTS:** bsr-inc.com

We're all here to learn how to drive when things go sideways, whether in downtown D.C. or one of the world's finest hellholes. Haas, who has a racing background, is the professor for our three-student group. He's got good material, which helps take the edge off when he's delivering news that you just made a mortal mistake. "There's the difference between steering and chocolate syrup," Haas tells one of the students after he slides off the wet skidpad. "You can't have too much chocolate syrup in your glass of milk, but you can have too much steering in a skid."

That was the first day, which is generally devoted to car control, learning to push the limits of your vehicle. Upon that foundation come exercises you'd hope you never use: spinning out a car in front of you, ramming, and reverse-J-turns—that movie move where a car in reverse suddenly does a 180. What happens when your tires get shot? (They take a long time to go flat, actually.)

Much of the training focuses on reactions and how you deal with stress. In one exercise, we learn how to take control of a car from the passenger seat—in case, you know, the driver is no longer capable. One moment Haas is driving a relaxed lap of the track, commenting on the

fine weather, the next he's slumped over with the throttle floored, heading toward a corner. My classmate up front grabs the wheel and frantically gets his left foot over to the brake. "You didn't tell me you were going to hit the gas!" he yells. "Yeah, dead guys are pesky like that," Haas replies. The other guy in our group performs flawlessly. "I've actually had to do that before," he says. "It's a lot harder in a Humvee."

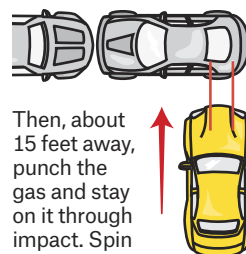
I goof up on an important test. A car following ours swerves and blocks the road. Then the car ahead stops, disgorging assailants who open fire on us with paintball guns. I start to hit the brakes, with the idea that I'd ram the car behind us to make my escape. But Haas points to a car-width of open pavement ahead of us and yells, "There's your out!" I go back to full throttle and hit the gas as paintballs splatter the windshield. In this test, going forward was the right answer.

These scenarios are geared toward war zones, places where everyone hates you. But the broader lessons are useful to have in the back of your head even during the morning bagel run in Suburb, USA: Any action is better than no action. Stay alert to your surroundings. And never help a guy who pulls up asking for directions to Walmart.

YOUR PLAN OF ACTION WHEN...

- ▶ You round a corner to discover a nose-to-nose vehicle blockade.

Time to ram. Pick one car or the other—no need to hit them both—and line up your driver's-side frame rail (about a foot inboard of the tire) with the other car's C-pillar, the one behind the rear door. Slow down, and maybe even act like you'll stop.



Then, about 15 feet away, punch the gas and stay on it through impact. Spin the blocker out of the way and you're gone.

- ▶ You're outside your car and bullets start flying.

Crouch behind the front axle. That's where you've got the most metal—engine block, transmission—to stop incoming rounds. Hollow areas are bad: Even a 9-mm can punch straight through both doors or the trunk. Second choice? Rear axle.

- ▶ You're driving and a car of gunmen pulls alongside.

Hit the brakes, hard, and get into reverse as quickly as possible. Instinct may say to hit the gas, but even a Bugatti Veyron will take a moment to downshift and initiate acceleration. When every moment counts, braking makes for the quickest escapes.

What's Really In Your Fuel Tank???

The Facts of Fuel

Today's fuels are engineered to be cleaner burning for reduced emissions; while this is good for the planet, it comes at the cost of lost engine performance. The new compounds the fuel refiners utilize to reduce emissions and meet government mandates also reduce horsepower, fuel life and fuel economy. This fuel fact is true for all blends of fuel from E0 (non-ethanol fuel) to E-10, E15 and even E85 Flex fuels. This trade-off of clean burning gas versus full performance means fuel chemistry has changed, and these changes could be here to stay. Today's fuels also tend to develop gum, varnish and carbon deposits more readily, which adversely affects all engines, from the smallest lawn equipment to the largest truck or car engines.

What if You Could Have the Best of Both Worlds?

By treating fuel with Star Tron Enzyme Fuel Treatment, you can ensure that it burns even cleaner while restoring lost power. Star Tron Enzyme Fuel Treatment is a multifunctional product that does more than "just stabilize;" it improves combustibility while treating debris and moisture in fuel. It works in all fuel, including E0, E5, E15 and E85.

By improving combustibility, Star Tron helps achieve a more complete burn of the fuel charge, which results in maximum power and fuel economy. It also reduces emissions while keeping fuel delivery systems clean. Some mechanics actually rely on Star Tron to clean carburetors and fuel injectors.

Be careful what you put in your tank; many fuel treatments contain alcohol or alcohol derivatives. Adding alcohol to fight alcohol-related problems may actually worsen the situation. Star Tron's alcohol-free formula is simple: a blend of proprietary enzymes in a fuel suspension, which means there is no danger of overdosing the product.

Stabilizing Fuel

Fuel in equipment that will not be used for extended periods of time such as seasonal gear - boats, motorcycles, snowmobiles, RVs or outdoor power equipment - needs to be stabilized. Traditional stabilizers can decrease the combustibility of fuel, resulting in engines that run rough and smoky or are difficult to start in the spring. In addition to stabilizing fuel for up to 2 years, Star Tron helps improve fuel combustibility so engines start easily and run strong when they come out of seasonal storage. By preparing for winter, engines are ready for spring.

Living with Ethanol

There is no miracle product that can remove ethanol from fuel or neutralize it. Your best defense is proper fuel management: use a quality fuel additive, store equipment with full tanks, purchase quality fuel and most importantly of all, drive!



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1 2016 KIA SORENTO

→ It's hard to draw a conclusion about the Kia Sorento, because there are so many Sorentos from which to draw conclusions. Front-wheel drive, all-wheel drive, two- or three-row, four-cylinder, V-6, turbo four-cylinder, green pepper with extra cheese. There are 15 distinct Sorentos, so let's just focus on the one I think you'd want: the EX V-6 AWD. That one brings the **290-horsepower V-6** mated to an all-wheel-drive system with a locking center differential. The locking diff splits power evenly front to rear and might be handy on a slimy boat ramp if you were testing the **5,000-pound tow rating**. Even if you never used it, it's cool to know that you have 33 percent as many locking differentials as a Jeep Wrangler Rubicon—and 100 percent more lockers than most other crossovers.

The Kia's 3.3-liter V-6 is a sweet motor, happy to rev, with no coarseness to it. The power-steering motor is mounted directly to the rack, enhancing feedback. The EX model gives you leather and most of the options you'd want in your daily driver. The one I tested cost about \$37,000, which seemed about right. But I also tested an SX Limited with the turbo four, and that one cost a heady \$45,000. Which points to at least one conclusion: If ordering the merlot nappa leather seats causes your four-cylinder Kia to cost as much as a Hemi Dodge Durango Limited, maybe you can skip the nappa leather seats.

2 2016 MINI JOHN COOPER WORKS HARDTOP

→ I drove the Mini John Cooper Works in Boston, where it was the perfect solution for ruthless urban driving: plenty of power for cutting people off, tidy size for parking, and enough interior room to make Home Depot runs (among other things, I fit a set of 78-inch folding doors inside). It's incredibly gratifying to depart a precious parking space and return an hour later to find it's still vacant because nobody else could fit. Also gratifying: throttling up the **2.0-liter turbocharged four-cylinder** and ripping a 5.6-second run from 50 to 75 mph.

The JCW is a serious performance car disguised as a chipper little Mini. With **228 horsepower**, this is a Cooper that happens to do 153 mph. And if anything, it feels like it has even more power than that, such is the drama of the soundtrack: The exhaust pops and crackles at high rpm, and the turbo dumps excess boost with an audible whoosh, sounding like a race-tuned World Rally Championship car. You'll want to avoid potholes (the 17-inch wheels are barely sheathed by the low-profile tires) but then, slaloming potholes is part of the fun. You're in your own private race wherever you go—unless someone decides to join you in some spirited driving, as happened when a Subaru WRX driver noticed that he was tailing a Works model and tagged along for a bit. Yes, the guy in the WRX could've dusted me. But I'm not sure he was having any more fun.

3 2016 LINCOLN MKX

→ The new MKX arrives on a mission to distance itself from the Ford Edge, its corporate cousin. Aesthetically, that's a done deal, as the MKX no longer looks like an Edge dressed up for prom. (In fact, it doesn't look like an Edge at all.) Dynamically, though, there's a tougher challenge: Artful tuning can accomplish only so much when you've got a shared chassis, **2.7-liter EcoBoost engine**, and **six-speed automatic transmission**.

So, then, what does the MKX give you that the Edge doesn't? Swag. Lincoln hopes to target the Audi Q5, so the MKX is available with the full raft of modern luxe must-haves: open-pore wood trim, a snooty high-end stereo (Revel), 22-way adjustable massage seats draped in the supplest of hides. A forward camera hides behind the Lincoln grille badge and pops out to help stitch together a 360-degree view. **The twin-turbo V-6 is tuned for 335 horsepower**—20 more than the Edge—but there's a notable caveat: Even though the MKX doesn't require premium fuel, the rated power number was recorded on 93 octane. Fill it with regular, and it's probably back around the Edge's numbers.

But do Lincoln buyers care whether they've got 335 horses or 315? Probably not. They just want something that's a step up from the equivalent Ford. And that's certainly the case. Whether the MKX steals any Audi buyers remains to be seen.

FIVE-
WORD
REVIEWS



**2015 SUBARU XV
CROSSTREK** Romans
call it Crosstrek 15.



**2016 CHEVROLET
TAHOE** Luxurious
and huge. Feels huge.



**2016 DODGE
DURANGO** Luxurious
and huge. Feels cozy.

There is something **TERRIBLY WRONG** with the Home Security Industry

Hi. Maybe you've been broken into before, or maybe you haven't. But if you ever decide to protect your home against unfortunate events like that, you're in for a shock. We don't want to scare you off of protecting your home, because honestly, it's really important that you do it. But we feel responsible for sharing these facts with you: Most alarm companies take advantage of people who want to feel safe. They offer you a "free" outdated alarm, but then require you to sign a long-term contract full of nasty fine print. It's pretty sickening really...but this isn't going to be all bad news. There is a better way to protect your home—get a SimpliSafe home security system. Our founder, a Harvard engineer, studied the alarm industry and found all kinds of problems with it. He designed SimpliSafe to fix them, so you can be safe, without having to spend a fortune or sign any contracts. SimpliSafe is wireless, you can order it online, and it's easy to install yourself—anyone can do it. It fits any home, apartment, or business. And it's more affordable, more reliable, and stronger than just about anything else out there.

Most companies say "trust us" and then ask you to sign on the dotted line. We're asking you to let us prove that a SimpliSafe home security system is the smarter choice. Try SimpliSafe for 60 days. We think you'll love it. But if you don't, that's okay too. Return it to us for a full refund, no questions asked.



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—Dave Ramsey, financial expert & New York Times bestselling author

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A Beautiful Thing

YOU DRIVE THE KIDS a half hour to the Christmas tree farm. Trudge another half hour searching for the perfect Douglas fir or Scotch pine. Drop to your knees and hacksaw so furiously you'll feel it in your arm the next morning. You do this because it means more than stopping for a precut tree from the lot near the mall. Because hard-earned memories last longest. Same goes for untangling the lights and unwrapping the heirloom ornaments. So why then would you settle for a soulless, chintzy plastic tree stand?

Floyd Bowling didn't. In December 1989, the Bear Lake, Michigan, farmer was stunned by how much a local Christmas tree seller was charging for shoddy stands and decided to make his own. He and his 24-year-old son, Floyd Jr., dug up some irrigation pipe from their fields and welded on bar stock for legs. Then they built enough stands to fill Floyd Sr.'s flatbed and took their product on the road.

"We were staying in Motel 6s," Floyd Jr. says. "We didn't have any money. But we had ambition. We'd drive down the main streets of towns and whenever we saw somebody selling Christmas trees we'd stop. This was before cellphones. A week went by and we called my mom and she said, 'Hey, those people that you sold tree stands to, they keep calling. They're out of 'em.'"

So we went back home and dug up a whole bunch more pipe."

Floyd Sr. died in 2004, and Floyd Jr. now outsources steel instead of excavating it. And thanks to the Internet he no longer has to hawk the stands out of a truck. In fact, to keep up with thousands of annual orders, he's turned a former migrant-worker dormitory at the Bear Lake farm into a modernized assembly line. The six sizes of stands—the most popular costs \$130, weighs a healthy 20 pounds, and can support a 9-foot-tall tree—are mostly welded robotically and then painted by submersion, several at a time, in a 350-gallon vat of Rust-Oleum Regal Red.

But the operation isn't entirely automated. The labels and the trunk-stabilizing T-bolts—used instead of eyebolts for easier turning—are affixed by hand, often by Floyd Jr., his mother, and his wife, Patti. The Bowlings' five grown children help out, too, whenever they're home for a visit. That includes Christmas, when the family hikes into their woods, chops down a tree, hauls it home, and places it in a stand they built 17 years ago.

—SEAN MANNING

The Christmas Tree Stand Your Kids Will Fight to Inherit

Company:
Bowling
Enterprises

Location:
Bear Lake,
Michigan

Founded:
1989





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Disney

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THE PK GRILL \$370

The smoke you create when you cook up some hamburgers over a charcoal fire is bracing, full of fragrant char and the fresh punch of beef. The smoke that hisses from a smoker is an altogether different smoke: earthy and slow, smoke that wraps around you and sweetens the whole neighborhood. This portable kitchen—that's what the PK stands for—gives you both at the same time. The inventor, one Hilton Meigs, designed it with a four-way venting system when he built the original in the 1950s and sold them out of his car. Today they're made in Little Rock, Arkansas. Use it year-round.



PHOTOGRAPHS BY JESUS AYALA



GUIDE



"That's all it took to solve problems—just sense."
—FROM *HATCHET*,
THE CLASSIC BOOK FOR BOYS
BY GARY PAULSEN

**SPIKEBALL \$59**

This first had its moment in the '80s. And like nearly everything else from the '80s, Spikeball is having a moment again. It's Foursquare meets beach volleyball, and now it's back. What's not to love?

**PATAGONIA SNAP-T \$149**

Thirty years ago, Patagonia started making a fleece pullover. It soon became standard equipment for mountain climbers, Arctic explorers, and college students in cooler climates. To celebrate three decades of this outdoor-wear icon, Patagonia is releasing a special collection of Snap-Ts that includes this cotton-quilted edition, suitable for campfires, rock faces, and that bar where they have the two-for-one beers.

BEST MADE STRAIGHT-HOLD HATCHET \$85

Forged of 1060 alloy steel and hand-ground, and equipped with a strong Appalachian hickory handle, survival now weighs in at 1.25 pounds.

**SURVIVAL
Tip!****HOW TO GIVE A GIFT**

- ☒ Hand it to them. Say "This is from me."
- ☒ Let them open it. Don't say anything.
- ☒ Tell them what they can do with it. For example, if it's binoculars, say "Now you can go birding, like you've been talking about."
- ☐ Don't say how much money it put you back or how difficult it was to track down.
- ☒ If they say "Thank you," say "You're welcome."



STORMY KROMER ORIGINAL CAP WITH HARRIS TWEED \$60

George "Stormy" Kromer was a real guy. He invented this hat that had flaps so it wouldn't fly off when he stuck his head out a train window. They make it up in the northern reaches of Michigan in the Upper Peninsula, and this model is sewn with genuine Harris tweed, a tweed of such high caliber that its quality and authenticity are certified by the Scottish parliament. Old Stormy wouldn't know what to make of that, other than to be rightly proud.



SAGE ONE FLY FISHING OUTFIT

\$1,050

Prepackaged rod-reel-and-line kits can feel a bit all-purpose to purists, but as those go, you won't find any better than the Sage One outfit. The rod is made of tightly packed bundles of carbon fiber for lighter, more accurate casting. The reel is made of machined aerospace-grade aluminum. All of it is made just outside Seattle.

GRAMOVOK FLOATING RECORD \$400

Turning a record player sideways means out-engineering terrestrial physics. A precision weight at the base of the tonearm keeps it radially balanced and negates gravity's downward pull. A spring gently holds the needle to the groove. The belt drive and rubber bushings stretch and compress to absorb any vibrations from the motor. Only mention this stuff if the giftee asks. Watching (hearing) it in motion is hypnotic, no explanation necessary.



YETI RAMBLER LOWBALL

\$25

Fill it with four fingers of bourbon and a few ice cubes. It won't sweat on you. Or pour into it a good cup of coffee. It won't burn your hands. Have it take a tumble down a mountain. It'll just come out looking better.



CASE XX TOXXIN KIRINITE TRAPPERLOCK KNIFE \$94

Open a package. Slice an apple. Clip a loose thread. Sharpen a pencil. Cut off the tags. Pry a bullet out of your shoulder. See, there are lots of things you can do only if you have a sturdy knife in your pocket at all times.





GUIDE



► Remember that face you made when you took your bicycle down a hill and found yourself going just a little faster than felt safe? These motorized people-movers give that same kinetic thrill, complete with the involuntary smile at the end. Warning: These can be hazardous, so wear safety gear. And don't get one for your child. (Get one for your niece or nephew instead.)



ONEWHEEL \$1,499

Dominant foot first—the sensors activate the balancing mechanism and start the motor. Lean on the front foot to go forward, back foot to slow down. Pick up speed. Feel the relative wind on your face. You're laughing—the top speed of 15 mph feels a lot faster. You feel as if you're carving snow, or a wave, and yet you are simply soaring through the park. Everybody's watching, and it's spectacular.



MONOROVER R2 \$599

Behold, the mechanized, gyroscopic evolution of homo erectus. Stand with your feet parallel to the wheels, and lean into your intended path. It's unsettling to see a human on one of these, moving through space while standing still. This is Wright brothers stuff. *Jetsons* stuff. There you'll be, flying down the sidewalk, looking forward to 2016 from 50 years ago.



BOOSTED BOARD \$999 AND UP

Your childhood doodles realized: powerful compact batteries, a belt drive, and a flexible bamboo deck that can hit 20 mph. Warning: Our board's belt broke under normal use. Replacing it is \$25 and 30 minutes of dexterity.



► **THE SECRET:** When riding any of these, don't look at your feet. Chin up, and look where you want to go.



UE BOOM 2 \$200

Of the hundreds of Bluetooth speakers available, this is the one worth buying. Waterproof (for the poolside), loud (for a house party), and with a sensor that lets you skip songs by tapping the top of the cylinder (like when an Elvis Christmas song pops onto your playlist at the wrong time).

CATALYST CASE FOR APPLE WATCH \$60

You took your Watch off while swimming laps. At the end of the day, the Activity app says you're a bum, and there's no changing its mind. In this case, take your Watch anywhere, all burned calories accounted for.



COZOY ASTRAPI \$130

For all their strengths, most smartphones have a lousy digital-to-analog converter—the component that translates audio data into signals that headphones can process. Plug the Cozoy amp into the data port, add some decent headphones, and songs gain dimension (and volume) that's normally lost to the din of commuter trains and jet engines.



RAM X-GRIP AND MOUNT \$55

With a cheap dashboard holder, your phone will tumble down into the crevasse between the seat and the drivetrain hump, lost until you dig it out, smeared with old coffee and Cheerio dust. The patented locking mechanisms and suction cups in RAM mounts are used in military aircraft because they keep devices in place through rock-polisher turbulence. So it should work fine in your Mazda.



HOW TO CHANGE GRANDMA'S COMPLICATED DEFAULT WI-FI PASSWORD

1

► Verizon:

Connect, and type <http://192.168.1.1> into a browser.

► Xfinity/Comcast:

<http://10.0.0.1>

► Time Warner:

<http://192.168.0.1>

► AT&T:

<http://192.168.1.254>

If it requires a login, it's usually "admin" and "password," or written on the router.

2

Turn off the WEP key if it's on, then find WPA or WPA2, usually under Advanced Settings. Change the network name (SSID) and the password to something a human can remember.

3

Receive thanks from siblings and other visitors.





GUIDE



AWKWARD ENGINEER VOLTMETER CLOCK \$139

Sam Feller has a fantastically weird and creative mind. Exhibit A: His company is called the Awkward Engineer. Exhibit B: This oddly desirable clock fashioned after a 1950s voltmeter. It works.

FILSON SCOUT WATCH \$700

Filson: heritage American brand that got its start in the 1890s selling blankets and boots to prospectors en route to find gold in Alaska. Shinola: upstart American brand that got its start making designer wristwatches in washed-up Detroit four years ago. The pilot-styled watch the two make in partnership: heirloom-quality, fits-in-anywhere style, everyday functionality.



HUDSON HOCKEY CO. MIRACLE GOALIE STICK

\$130

When a pack of American college kids defeated the mighty Soviets at the Lake Placid Olympics in 1980, they did so with wooden hockey sticks. Hudson Hockey Co.'s Miracle Goalie Stick is a throwback to those days before composite materials dominated the sport and Kurt Russell confused our memory of that legendary game.



WALTZING MATILDA GROWLER BACKPACK \$250

Fitted with leather straps from Chicago's legendary Horween tannery and hardware tooled in Waltzing Matilda's own Pennsylvania factory. Because you're a few years removed from shouldering a cask to the fraternity house.



PORTLAND GROWLER CO. LOOP GROWLER \$69

People in Portland, Oregon, care about craft IPAs. Deeply. Portland Growler knows this and is just as serious about its slip cast ceramic beer vessels.



PUBLIC-SUPPLY NOTEBOOKS \$12-\$20

A notebook for your ideas that helps spark new ones in schoolkids. Public-Supply donates 25 percent of profits from each purchase to high-need classrooms.



SHWOOD CANBY 50/50 OXIDIZED SUNGLASSES \$199

The oxidized brass inlays embedded on the sides of these shades make for the most stylish way ever to explain electron exchange to whoever's sitting next to you.

SURVIVAL Tip!

WHEN CAN YOU HAND-MAKE A GIFT? A BRIEF QUIZ



Are you a skilled craftsman or hobbyist?

YES	NO
☐	☐

Have you got more time than money?

☐	☐
--------------------------	--------------------------

Is it for "the man or woman who has everything"?

☐	☐
--------------------------	--------------------------

Everything but a home-made ceramic ashtray?

☐	☐
--------------------------	--------------------------

Are you seven?

☐	☐
--------------------------	--------------------------

- If you answered Yes to more than half the questions, make that gift!
- If you answered No to more than half the questions, buy that gift!
- If you answered both Yes and No, make the card by hand!



SPECIAL EXTRA PAGE!



Shazam this page to see over 25 more Toy Award winners (and where to buy them). For instructions, see page 11.

TOYS FOR KIDS

► For our second annual Popular Mechanics Toy Awards, we tested the best of this year's new toys with the help of more than 30 kids over two days in our New York City offices. Featured here are six of the winners.



BRACKITZ \$30-\$100

As a general rule, the less structured a toy, the better. That's why we like Brackitz, a new type of building set created by a dad in Salt Lake City. It's just wooden planks and two types of plastic connectors—an open building experience that can be as simple or complex as the kid's vision.

HAPE VIBRANT RED GUITAR \$70

Sturdy, lightweight, and easy to hold. In our testing, almost every kid picked it up.



SPHERO BB-8 \$150 AND SPRK EDITION \$130

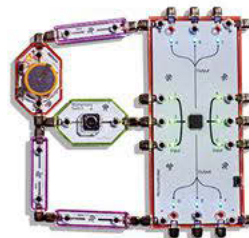
Sphero's gyroscopic, smartphone-controlled robot balls are already fun to drive around, but the new SPRK Edition is made with education in mind: The clear shell allows kids to see the ball's sensors and internal workings, and the app now lets kids learn how to code specific movements. The BB-8 is

a miniaturized version of a droid from the new *Star Wars* movie, *The Force Awakens*. The body uses the same technology as a regular Sphero ball, but the added head is kept on top using magnets. An augmented-reality feature within the app lets you record and play holographic messages.



CANDYLAB TOY CARS \$25-\$39

Earlier this year, the company wrapped up a second Kickstarter campaign to fund more of its solid beechwood cars. Each Candylab ride is painstakingly designed and engineered, but our favorite is the new Woodie, which comes with a magnetized surfboard and will also tow a trailer using a magnetic hitch.



LIGHTUP TESLA KIT \$100

Remember learning about circuits using a lightbulb, wires, and a potato? That's the point of LightUp's kits, minus the root vegetable. Each set comes with various circuitry components—LEDs, resistors, buzzers—and an app to guide you through the projects. To check your circuit, just hold a Bluetooth-connected tablet or phone above it. A screen overlay will show you if electricity is flowing. The Tesla kit also includes an Arduino-based micro-controller for more complex builds.

SURVIVAL
Tip!



BECAUSE MAN CANNOT SURVIVE ON AMAZON ALONE

A brief roundup of stores, brick-and-mortar and online alike, for the confounded.

► **WestElm.com/Local**—Outposts of the interiors store are curating items made by neighborhood artisans, so you can give a local gift.

► **MakersRow.com/store**—Clothing, leather goods, and great home-design products from manufacturers dedicated to making in the USA.

► **Your local hardware store**—A set of kitchen knives, a new drill driver, the supplies to make something yourself. There's something for everyone there.





RIGHT NOW, ON A MILITARY BASE IN TUCSON, AMERICAN FIGHTER PILOTS ARE TEACHING A GROUP OF ELITE IRAQI AIRMEN HOW TO FLY THEIR COUNTRY'S FIRST F-16s.

IN THE U.S. THEY'VE FACED A STRANGE CULTURE, LONG HOURS IN THE SKY, AND A DEADLY CRASH.

BACK HOME LOOMS A GREATER CHALLENGE, THEIR ULTIMATE TARGET: ISIS.



BAGHDAD, ARIZONA

**STORY AND
PHOTOGRAPHS BY
ELLIOTT
WOODS**

**PM
PG 85**

OVER

FOUR DAYS IN EARLY SEPTEMBER, Iraqi fighter pilots carried out fifteen air strikes against Islamic State targets in Salah ad Din and Kirkuk provinces, just north of Baghdad. The story didn't get much play. Five short sentences in the Associated Press, with a canned quote by a Pentagon spokesman and few details. None of the major news networks paid any mind. *The Guardian*, one of Britain's leading daily newspapers, presented a marginally fuller picture: The planes were American-made F-16s, among thirty-six ordered by the Iraqi government back in 2011. The United States had repeatedly delayed delivery of the jets, citing safety issues as the Islamic State group, or ISIS, became a direct threat to Balad Air Base—the jets' future home. Of course, ISIS was the very

reason Iraq now needed the planes urgently, and eventually the first four arrived in July. Still, *The Guardian* largely dismissed the delivery of the F-16s—the first ever in the history of the Iraqi Air Force—saying they would not be “a game changer” in the fight against ISIS.

It had been more than a year since ISIS had captured Mosul, Iraq's second-largest city, prompting the intervention of a coalition led by the U.S. Air strikes had targeted ISIS territories for much of that year. So you could understand how the news media didn't think fifteen more carried out by four Iraqi planes would change the fight in a fundamental way. But how those pilots came to be flying those airplanes in the skies over their home country—that was a big change indeed. The men flying the F-16s had recently returned to Iraq from a base in Tucson, Arizona, another desert more than seventy-five hundred miles from Baghdad, where they had completed more than three years of training with United States Air Force pilots. They had lived among Americans, eating tacos at Mexican cantinas, trying to follow the NBA. They had missed their families, their own beds, the mothers' home-cooked meals, their hometowns. These men, who back in Iraq had learned how to fly in Cessnas and Beechcraft T-6 single-engine prop training planes, now knew how to control the mighty F-16 Fighting Falcon, a multimillion-dollar, Lockheed Martin-built military combat machine that can reach speeds of 1,500 miles per hour.

And they weren't the only ones. Back in America there were others. Around twenty. Iraqis just like them, learning to fly F-16s, training to fight ISIS. Though that number was one less since June, when one of those men had died.

No, in the twenty-four-hour news cycle, four Iraqi Air Force pilots flying some bombing runs in a confusing and far-off war didn't merit a mention in the crawl along the bottom of your television screen. And yet to the pilots who flew the missions, and to the rest still in Tucson counting the days before they could return home to do the same, and to their wives and children and mothers and fathers, and to the family of the man whose F-16 crashed in an eruption of flames in the Arizona desert just days before he was supposed to return to Iraq to help lead the fight—to them, it was everything.



An F-16 in the 162nd Wing's “hush house,” a soundproof hangar where engines are tested.

E

AST VALENCIA ROAD, a thirteen-mile stretch of strip malls, *carnicerías*, industrial parks, and chain hotels, runs alongside Tucson International Airport. Three years into their training program, the Iraqi pilots have done their best to fit in here. They live in small apartments near the airport, on the city's south side. Some drive American muscle cars, bought with their pilot salaries. The younger ones have discovered Congress Street, a downtown district full of craft breweries and tequila bars where University of Arizona students go on the weekends. They've also discovered Las Vegas.

The weather is like home, pretty much—dry and hot most of the year, except for a few weeks of summer thunderstorms that locals call the monsoon. The reliable climate makes Tucson a great place to fly. Only 3 percent of all sorties are canceled due to dangerous conditions. Take away the towering saguaros and the Sonoran desert looks a lot like Iraq—especially from the sky. But on the ground America is so much different.

Its mix of skin colors. Everyone free to go about their business—the kids, the groceries, the job, the errands, the night out, the sick day, the golf game, the business trip, the oil change, the early-morning meeting—without worrying about suicide bombers. The Iraqi pilots move among a population unaware of where they're from, of who they are, of what they're doing.

Nawaf has been in the U.S. since 2011. (Nawaf is not his real name. For the protection of his family, his colleagues, and himself, the Iraqi Ministry of Defense allowed him to be interviewed only on the condition of anonymity. Neither would they permit photography of him or the other pilots—or even provide the exact number of pilots in the F-16 training program, though earlier news reports estimated twenty-four.) His family—mom, dad, a sister and two brothers—lives in Sulaymaniyah, though for most of Nawaf's life they lived in Kirkuk, just under seventy miles west, an ancient city as famous for the diversity of its population as for its oil fields. Arabs, Kurds, Assyrians, and Turkomans, Christians and Muslims, Sunni and Shia all live there. Nawaf is a Kurd. Now twenty-five, he was barely a teenager in March 2003, when one thousand members of the U.S. Army's 173rd Airborne Brigade parachuted into Kirkuk to open the northern front in the Iraq War—one of the largest airdrops since World War II. In 1988, near the end of the Iran-Iraq war, Saddam Hussein fatally gassed thousands of Kurds. Nawaf's family and neighbors anticipated a similar attack in response to the American

invasion. "We were afraid Saddam would do something terrible," he says. "We made gas masks and prepared our cars to flee the city. The car had to be ready with everything in the trunk, even food, 24/7." The chemical attack never came, and Kirkuk was quiet in the early years of the U.S. occupation.

Violence increased as Nawaf got older, but that's not why he enrolled in the Iraqi Military Academy in 2008 as an Air Force candidate. His father had been a conscript in Saddam's army and wanted to be an Iraqi Air Force pilot, but there was no chance. Nawaf's father was a Kurd, and Kurds were not allowed to be pilots. "I'm doing this for my dad," Nawaf says.

In September 2011, with American forces pulling out of Iraq and taking their air superiority with them, Iraqi Prime

Minister Nouri al-Maliki purchased eighteen brand-new F-16s from the U.S. with the goal of rebuilding an Iraqi Air Force capable of defending its own airspace. Two decades earlier, Iraq had been the most feared air power in the Middle East, with more than a thousand aircraft mostly obtained from the Soviets and the French. But after Saddam invaded Kuwait and the Gulf War began, nearly all of Iraq's aircraft were destroyed by the Americans or flown to Iran, first by defecting Iraqi pilots, then under direct orders from Saddam. The ensuing no-fly zones further curtailed the Iraqi Air Force, and the 2003 American invasion completed its destruction.

By 2004, the Iraqi Air Force had just thirty-five personnel and zero aircraft.

In December 2011, al-Maliki ordered another eighteen F-16s, bringing the total cost to around \$6 billion. This sum included the jets themselves, along with a standard package of 20-mm Vulcan cannons, hundreds of missiles and laser-guided bombs, targeting pods, and all necessary communications and navigation systems. The per-unit sticker price of roughly \$165 million also included sending pilots to America for F-16 training. A group of six came first, the others arriving in small groups over the months that followed.

They started at San Antonio's Lackland Air Force Base, where they spent four months learning English. Then it was on to Laughlin Air Force Base in Del Rio, Texas, where they took Undergraduate Pilot Training—the Air Force's introductory flying course—proving themselves on the single-prop T-6 Texan II. From there, they advanced to the dual-jet T-38 Talon at Columbus Air Force Base in Mississippi. Then it was back to San Antonio, this time to Randolph Air Force Base, for eight more months in the T-38, practicing evasive tactics and air-to-air combat. Finally, they headed to Tucson International Airport, home of the 162nd Wing of the Arizona Air



The view from a two-seater D-model F-16.

Brigadier General Hasan in his F-16, the same in which he would fatally crash.



National Guard, for the final phase of training in their very own F-16s. The instructors here are some of the most skilled fighter jocks alive, having flown combat missions in Iraq, the Balkans, and Afghanistan, and averaging three thousand hours in the F-16—the equivalent of flying nine-to-five every day for a year. Today, F-16s make up roughly 15 percent of the total aircraft in the world's air forces. For foreign pilots, Tucson is where it begins.

Tucson is where Nawaf was one night in late June, sitting in his one-bedroom apartment watching TV when the phone rang.

"You okay?"

It was one of his American friends. Nawaf said he was fine, thinking his friend was asking about the weight-lifting injury he'd been rehabbing.

No. On the news, his friend said. He'd just seen it. An F-16 had crashed near the Mexican border. Was he okay?

N PHOTOGRAPHS, the F-16's smooth contours, compact shape, and sleek gunmetal-gray skin make it appear lightweight and easy to maneuver. Even looking at it up close—measuring a modest forty-nine feet nose-to-tail, with a thirty-three-foot wingspan—it seems like a delicate thing. It's only once you're in the cockpit, enclosed in that seamless bubble canopy, that you start to feel its complexity. Its ferocity. The ten-ton empty weight. The three multifunction displays by the pilot's knees that show a variety of data including thermal video from the targeting pods. The cameras that, at altitude on a clear day, can capture action on the ground from fifty miles away. The head-up display mounted above the instrument panel that allows the pilot to monitor vitals like airspeed, g-force, and bearing without looking down. The single Pratt & Whitney engine delivering over twenty-nine thousand pounds of thrust.

From way up high, it's hard to tell when you're going supersonic. The world appears stationary, like a photograph. It's hard to tell you're moving at all. "It's like you're not sitting in a jet," Nawaf says. "It's like you have wings, and you're flying all by yourself." Until you're rolling into an eight-g turn and feel the blood rush from your head as your g-suit blad-

ders inflate. Or swooping down to five hundred feet, tearing across Tucson pecan orchards and over I-10, the plane's shadow fluttering over speeding cars as if they were parked.

The Iraqis spent many hours in the classroom learning skills as basic and necessary as taking off before they got anywhere near an F-16. Nawaf remembers twelve-hour days when he never laid eyes on a plane. Each classroom lesson was followed by simulator time, then finally real-time exercises with an instructor riding in the backseat of a two-seater D-model F-16. Eventually, the Iraqis began flying solo in the same jets they would take with them back to Iraq. They progressed to dogfighting and air-to-ground tactics, adapting skills they'd learned on the T-38 to the F-16. They practiced strafing runs on shipping containers in the nearby Barry M. Goldwater Range. Ground controllers from the U.S. military talked them onto the targets to simulate the kind of complex scenarios they would encounter back home. They learned to use laser-guided bombs as large as two thousand pounds. They also practiced dropping dumb bombs, the kind you have to aim the old-fashioned way, angling your jet in a dive toward the target, then quickly peeling away at an altitude safe from man-portable surface-to-air missiles—like the ones ISIS claims to have discovered in large numbers on captured military bases.

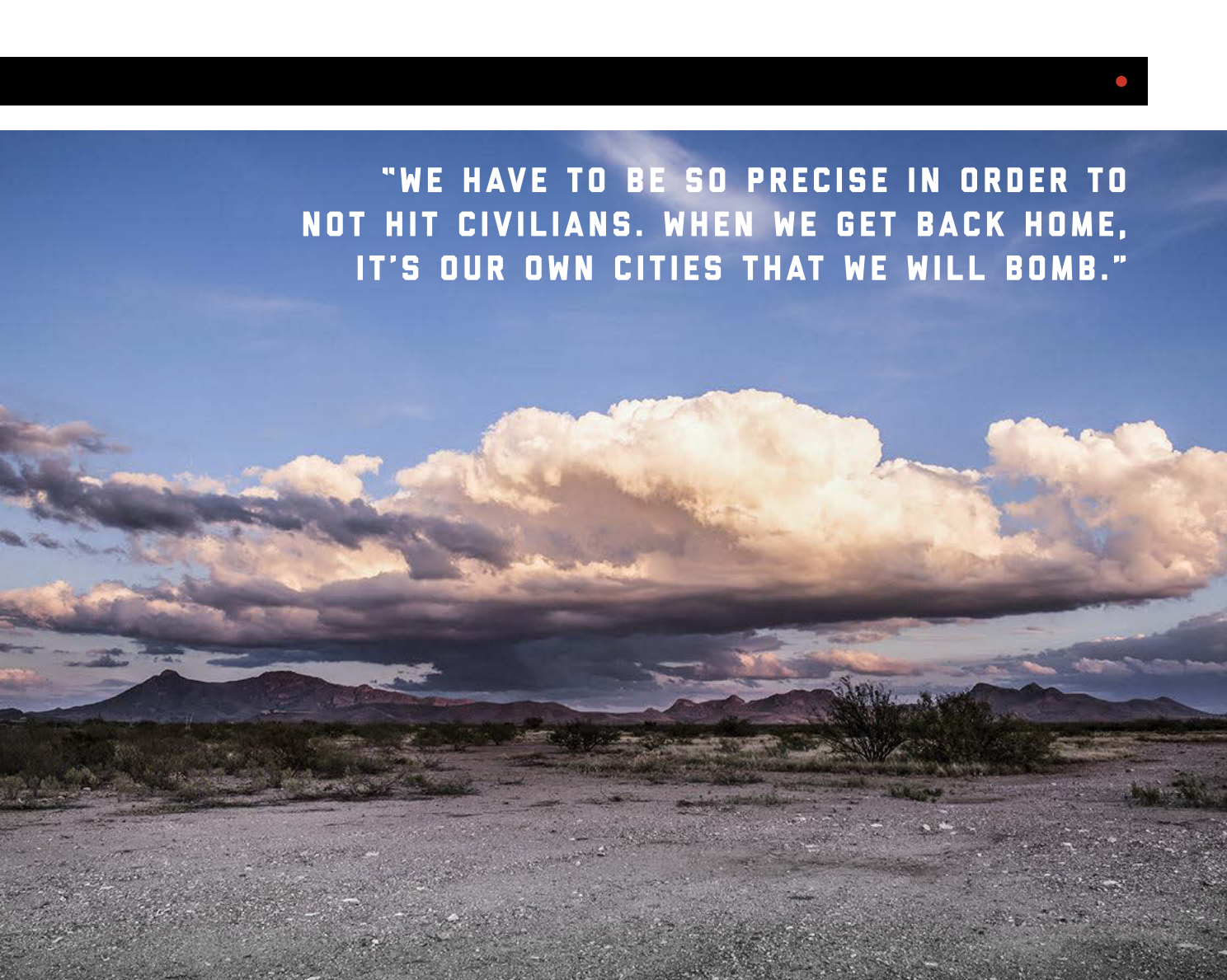
"We have to be so precise in order to not have collateral damage, not hit civilians," Nawaf says. "When we get back home, it's our own cities that we will bomb."

In 2014, Nawaf and the other pilots had watched the news as ISIS emerged, seemingly out of nowhere, to begin systematically tearing Iraq apart. Rolling into Iraqi towns in Humvees seized from fleeing Iraqi troops, waving their black flags. Capturing civilians, soldiers, policemen, and international reporters. The beheadings. That June ISIS claimed its most significant victory yet, seizing Mosul with fifteen hundred men against an Iraqi military force of thirty thousand. From there its fighters pushed into Kurdish territory, their clear objective to overtake Kirkuk, just a hundred or so miles to the southeast. Sulaymaniyah was not far from the advancing ISIS fighters.

Nawaf spoke to his family on the phone every day and they assured him they were okay. His father, who had once dreamed of being a pilot, wanted only to talk about Nawaf's training, always asking what maneuvers he'd practiced and what kind of targets he had attacked. Still, for Nawaf, thoughts of home were filled with uncertainty.

THE 162ND WING has trained pilots from the Netherlands, Turkey, Israel, Venezuela, Pakistan, Chile, and many other countries. Those trainees are usually in Tucson seven or eight months. Then they return home to train as wingmen with veteran pilots from their own militaries, until they're deemed "mission qualified"—ready to fly real-life combat missions. The Iraqi pilots couldn't go back home to train with veteran F-16 pilots because there *were* no veteran F-16 pilots in Iraq. And when the first pilots became mission-ready in 2014, Balad Air Base was not secure. So they stayed in Tucson, rooting for the Spurs, hitting the drive-through at Chickenuevo Mexican Grill, watching and waiting, staying sharp, flying four days a week.

The instructors offer as much reassurance as they can.



"WE HAVE TO BE SO PRECISE IN ORDER TO NOT HIT CIVILIANS. WHEN WE GET BACK HOME, IT'S OUR OWN CITIES THAT WE WILL BOMB."

"Every one of us has been deployed, whether a mobile training team for three months or an overseas deployment for a year," says Major Shayne Sullivan, thirty-seven, an instructor pilot in Nawaf's squadron. "We know how to deal with being away from family. We can talk through that."

Each day before going up in the air, the instructors talk to the foreign students to determine their mental state. With students from, say, Norway or Japan, these informal check-ins could be as mundane as asking what a student had for breakfast. With the Iraqis, the conversations might be about friends and family killed by gunfire or car bombs. If an instructor thinks a student is too rattled, he'll sit out the flight.

Mostly, though, the Iraqi pilots depend on each other for support. They come from different regions—Baghdad, the Kurdish north, the Sunni Triangle, the Shiite south—but they almost never talk about their sectarian identities. They hang out at each others' apartments making Iraqi food, like a stewed beef dish called *pima* or the Kurdish okra recipe that Nawaf's mother walked him through over the phone.

"We are Iraqis," Nawaf says. "We are family."

The head of that family was Brigadier General Rasid



The site near Douglas, Arizona, where Brigadier General Hasan's plane went down.

Mohammed Sideeq Hasan, call sign "Fitter," the NATO code name for the Soviet-built Su-20 he'd flown as a young pilot. He was a graduate of the Iraqi Air Force academy but only flew for a short time before Desert Storm and all that followed essentially grounded him for two decades. Now, at forty-five, nearly twice as old as the rest of them, he was back in the cockpit. With his black mustache and gold aviator sunglasses and general's stars on his epaulets, he cut the figure of an old-school officer from the Saddam era. But he was known around the base as an unfailingly warm and gentle man. He treated the young Iraqi pilots like nephews. He was the one they turned to when the grueling training became too much, or when they worried about their families so much it made them sick. Hasan stayed focused. While the others were out revving their V-8s on days off—Nawaf in his red 2014 Dodge Challenger, a 392 Hemi with matte black racing stripes down the hood, a radar detector on the windshield, and a tiny pair of traditional Kurdish shoes dangling from the rearview

mirror—Hasan would usually be sitting alone in his bare one-bedroom apartment studying, preparing for his role as Iraq's first-ever F-16 squadron commander.

Hasan had been married as long as some of them had been alive and had four kids, his youngest son born just months before he left. Now, the boy was counting numbers on his fingers—counting the days until Hasan's return. That's what he told his father when they talked over Skype on Wednesday, June 24. In just two days, Hasan was booked on a Turkish Airlines flight back to Iraq. The delivery of the first four F-16s had finally been scheduled for mid-July. He was assigned to be one of the first flight leads. He was supposed to be in one of those F-16s that, come September, would bomb ISIS. But there were still a couple last training flights. Later that night he once more climbed the ladder into his plane, streaked down the runway, and shot off into the Arizona sky.

NAWAF HUNG UP with his friend and called one of the other pilots who lived in his building, and they sped toward the airport. When they got to the base, they saw some of their guys standing outside the Iraqi squadron's building. They knew it was Hasan from the flight schedule. They stayed at the squadron building until 1 a.m. before driving to one of their apartments to wait for more news. The plane had gone down near Douglas, an old mining

AN EYEWITNESS SAW THE PLANE BANK LEFT AND THEN ALL OF A SUDDEN TUMBLE OUT OF THE SKY.

town of seventeen thousand residents just shy of the border, about a hundred miles from the base. Not much there but empty desert and mountains. The Tucson news broadcasts showed a cellphone video shot by a man who lived nearby. The flames were raging—brush fires stoked by the hydrazine in the F-16's emergency power unit, and piles of tires someone had dumped out in the creosote barrens. About 3:30 a.m., the pilots began to drift back to their own apartments. There was still no word about whether Hasan had managed to eject, but they knew how unlikely it was.

Only when the tires finally stopped smoldering a day later were the hazmat teams able to search for a body. No one knew what had gone wrong. It was a routine night training mission, a two-plane formation with an American pilot on one wing. The pair were headed back north to Tucson. An eyewitness told the newspapers he saw the plane bank left and then just all of a sudden tumble out of the sky.

Brigadier General Hasan was the first Iraqi F-16 pilot to die in training and only the second pilot to die in the twenty-three-year history of the 162nd Wing's F-16 program. The Air Force is still investigating.

Master Sergeant Jesús Enriquez had the job of cleaning out Hasan's apartment and packing his belongings for repatriation. Enriquez had bonded with him over the similarities between Arabic and Latino culture. They compared Mexican and Iraqi rice dishes, tortillas and an Iraqi flatbread called *samoon*. They talked smack about soccer. "He liked the English league," says Enriquez, a fan of the Spanish league. "We would talk about which was harder, who had better players." Mostly, they talked about their children. "I'm a father, he's a father," says Enriquez. "We talked about how much he missed his children and how fast they'd grown. The first thing out of his mouth was always, 'How is your family?' And I do that now—I learned that from him. Every time I meet somebody I ask them, 'How are you, and how is your family?'"

Hasan had made little effort to settle into his apartment, so there wasn't much to pack up. His gold aviators sat on an otherwise empty table.



← The men of the 162nd Wing (clockwise from left): Colonel Phil Purcell, Lieutenant Colonel Mike Martinez, Major Shayne "Tito" Sullivan, and Master Sergeant Jesús Enriquez.

"I always told him, 'Hey, I like those glasses,'" says Enriquez. "And he would tell me, 'They're older than you.'"



ON JULY 7, a few weeks after the crash, a Tuesday, a busy workday, about eighty pilots, crew chiefs, and base personnel filled the burgundy folding seats of the 162nd Wing's auditorium. Framed photographs of F-16s and MQ-1 Predator drones hung on the walls. The space was normally used for briefings and promotions. That day it would serve a different purpose. That day it would be the site of a memorial service for Hasan. Enriquez and the Iraqis did their best to make the place worthy of the man. They placed an Iraqi flag beside the U.S. and Arizona flags. They laid flowers on a table beside the stage. They brought in a large portrait of Hasan, standing with his arms crossed in front of his F-16, wearing his aviators.

Lieutenant Colonel Mike Martinez, a Roman Catholic priest and one of the 162nd's chaplains, opened the memorial with a nondenominational prayer. The Iraqi pilots wrote a eulogy. Martinez and Enriquez had helped them compose it. The words showed on a projector screen as an Iraqi pilot read them in Arabic: "General Hasan was our brother and our leader. By his outstanding example, he gave us strength and inspiration to sacrifice for our country."

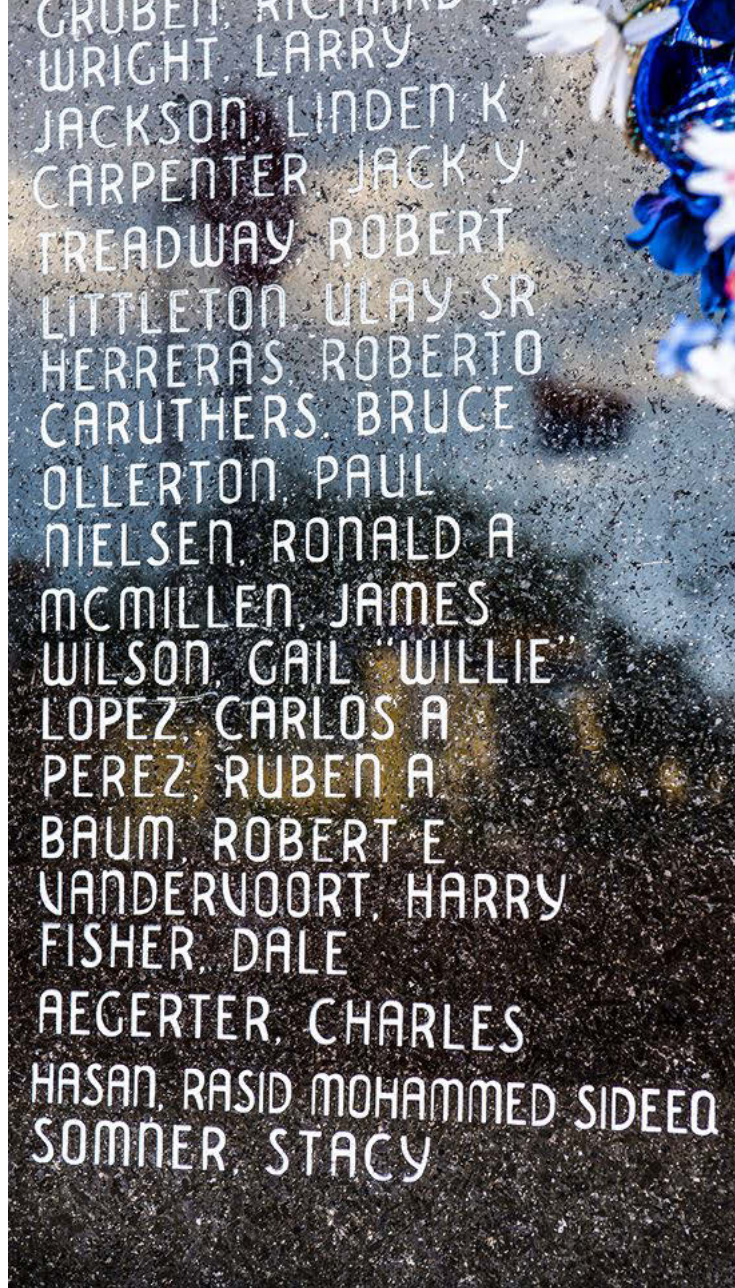
"We have lost one of our own and we grieve with his family and countrymen," Colonel Phil Purcell, commander of the Wing, told the airmen in attendance, who represented nine countries. "Every fighter pilot works hard to acquire the skills necessary to employ an F-16, but he did it worlds away from his home, his wife, and his children."

Lieutenant Colonel Brant Putnam then followed with a message intended for the Iraqi pilots: "Hasan said that his wish was for Iraqi pilots to be focused and work together in Tucson, so they could fly and fight as one cohesive unit. In so doing, you will become the fighting force your country sent you here to become. And the best part of all is that you will grant General Hasan his wish."

The Iraqis had understood this from the beginning. Nawaf still remembers the speech Hasan had given him when he first showed up in Tucson: "Now that you're here, you have to study harder than ever. You have to fly better than ever." Soon, Hasan constantly reminded the Iraqi pilots, they'd be back home, at the controls of F-16s with the Iraqi flag painted on the tail, dropping ordnance on ISIS.

"He always wanted to make sure that we flew well," says Nawaf. "He wanted us to be good."

The memorial service lasted about forty-five minutes, then everyone went back to work. The Iraqis had been given a week off after the crash to mourn but, ultimately, they found the best way of coping was being in the air. "It's total concentration," says Nawaf. "There's a saying that if you're in the jet and you don't think for a couple of seconds, something's wrong." So they flew.



When they finish—when they are mission qualified—the pilots will leave as they came, in groups of four, in pairs, or alone, adding their firepower to the fight against ISIS one F-16 at a time. Nawaf still has another year. The pilots who have returned to Iraq tell him they're thrilled to be doing their jobs at last. Nawaf can't wait to join them, but he's as nervous about going home as he was to come to the U.S. Once he's at Balad Air Base, he won't be allowed to leave because of the risk. And he's gotten used to living alone, to the ease of life here, to the freedom of the American highway. He's planning to bring his Challenger back with him.

Hasan's remains were returned to his family draped in an Iraqi flag. In Tucson, his name was engraved by hand on a polished wall of black granite, a memorial commemorating members of the 162nd Wing who have died. Guys named Dale, Willie, Bruce, James, Harry, Jack.

Hasan, Rasid Mohammed Sideeq. It barely fits on one line. But it fits.

PM

STUPID

OR

AMAZING

WE'RE ALL FOR TECHNOLOGY AND ADVANCEMENT, BUT IT HAS TO HAVE A TRUE PURPOSE.
HERE, A MINIMALLY BIASED LOOK AT A YEAR OF INNOVATION.

PHOTOGRAPHS BY
JEFF WILSON

PAGE
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TYPOGRAPHY BY
TRAVIS SIMON

DRONES

They're everywhere. Crashing into the seats at the U.S. Open. Crashing on the White House lawn. Drones may be getting more and more popular, but what can you really do with them? Does a normal person actually benefit from them? I decided to find out.

BY NEAL POLLACK





THEY SENT ME DRONES. Integrate them into my daily life, they said. It was going to be a challenge. My daily life tends toward the mundane.

“Can they fold laundry?” my wife asked. “Can they do dishes? Can they cook dinner? Can they drive carpool? Will they mow the lawn? Or vacuum? Or sweep out the garage?”

My wife and I share these duties. Neither of us likes any of them, except the cooking, sometimes, which we weren’t about to turn over to a remote-control flying machine.

“Probably not,” I said.

“Then what good are they?”

It was the million-dollar question. And not just for us, but for every American. Da-Jiang Innovations (DJI), the world’s largest personal drone-maker, is expected to hit a billion dollars in sales for 2015, double 2014 and four times its 2013 sales. The company’s largest market is the United States. Owning a drone is becoming as American a right as owning a gun; Congress has forbidden the Federal Aviation Administration from limiting hobbyist drone use, even if that means, as happened last year, those hobbyists occasionally fly their drones into the White House.

So drones are everywhere, but unless you make a living filming awesome surfing footage, their uses aren’t exactly clear. I thought I could have one fly into the kitchen and fetch me a beer. But someone would have to open the fridge, and place the beer on the drone. Someone else, probably me, would have to make sure that the drone flew the correct path back to me without dropping the beer. That seemed pretty inconvenient and difficult.

Domestic considerations were out. Drones weren’t going to help me work, unless one of them was a sentient typing drone. So I turned my thoughts toward leisure pursuits. Drones couldn’t help my pub-trivia team. I briefly considered taking the drones to play Frisbee golf with me. They could carry my bag. But the ones I had can’t lift more than two pounds safely. Also, I don’t play Frisbee golf.

My cleverest idea involved having a drone wait in my stead at Ramen Tatsu-Ya, where there’s always a line. I could put a “Pollack + 1” sign in its talons, and take photos of the hipsters watching the drone, whether they were amused, annoyed, or both. But even then I’d have to be nearby, making sure the drone hovered and moved forward. Also, even the sturdiest drone battery eats through

its charge in twenty-five minutes. You can barely get seated at Taco Bell in Austin in that amount of time.

There was only one option left, what’s more or less my favorite thing anyway: screwing around.

On a Sunday afternoon, my friend Jennings came over with his sons, who are fourteen and ten. Joined by my son, thirteen, we began with the Rolling Spider MiniDrone from a French company called Parrot. It came out of the box angry-looking and ready to party, the size of a small rodent. We easily snapped it together, attaching a flexible plastic axle with two large rubber wheels on either end to the top to form a sort of protective cage. Parrot recommended this for indoor use. We also gave it an ironic handlebar-mustache sticker, one of many that came in the box.

Parrot drones are operated via a free app called FreeFlight 3, which the Spider connects to via Bluetooth. All you have to do is pair your device, and then you can operate the drone. We chose my son’s iPad because it had the largest screen. The app was fairly intuitive. At first, I pressed Take Off. The Spider whirled to life, lifted off the ground, and hovered a few feet in the air, like a vicious, wheeled, red hell-bee. Buttons on the screen allowed the drone to shift directions and angle up or down, but motion also controlled it. I tilted the iPad. The drone gave a little wheeze, lurched forward, and slammed headfirst into my office door. It was a start.

The app made sense, as long as you remembered to keep your finger on the correct onscreen “button,” which helped glide the drone left or right. A left button rotated the drone. They were easy to get confused at first, and also every time I flew the drone.

We got the Spider down the hall to the kitchen and



The author operating DJI’s Phantom 3, his favorite drone.



cheered when it flew through the buffet opening into the dining room. Everything was going great. Suddenly, the drone's green eyes turned red. It dropped to the ground and started turning around madly in a circle, making crazy whirring sounds.

I rushed into the room to find the Spider running up and down my wife's leg, like a horny puppy, only with chopping blades. The Spider holds a charge for only six minutes or so, though it apparently doesn't die instantly, going through a dementia phase that's painful for everyone to experience.

Next, we went outside to try another Parrot drone, the Bebop, which is larger and comes with a built-in camera but is just as intuitive and easy to use, as drones go. By this point my son had gotten bored with drone life and kept his iPad indoors, so we used Jennings's Android phone, the next-biggest screen available to us.

The Bebop worked slightly differently than did the Spider. Because of the camera, you saw the street view on the app. Jennings's older son, Eamon, figured out pretty quickly that the best way to fly the Bebop was to look at the screen. If you tried to look at the drone while manipulating the screen controls, it would be disastrous. Needless to say, we flew it into every tree on the block.

But eventually we figured the drone out and even landed it safely a couple of times. The Bebop whizzed up and down the street merrily until Jennings lost control of it and thunked it onto a roof across the street. It sat on a slope pretty near the edge and would be easy to get.

I rang the doorbell. A couple of minutes passed. An elderly lady hobbled to the door. It was nearly 4 p.m. on a Sunday, so perhaps I'd woken her.

"Yes?" she said.

"I'm your neighbor," I said through the door, which she clearly wasn't about to open. "I flew a drone onto your roof, and I have to get it off. It won't take long."

Ten seconds passed. Finally, in the most reluctant tone possible, she said, "Okay." She clearly regretted having lived long enough to see the drone era come to pass.

Along with the Parrot drones, I got a box from a company called Axis Drones, in Rochester, New York. It contained four tiny drones, each about the size of a Girl Scout cookie and just as tempting. Two were prototypes, but the others, the Axis Nano Drone for Beginners and the Axis Turbo-X Drone—"The World's Fastest Nano Quadcopter"—are available now. These little drones operate on a six-axis stability system that allows them to do complicated flips with perfect balance. All you need are two AAA batteries and a USB charging port and you're set.

The Axis drones operated via a double joystick, like a very complicated Xbox controller. As a friend said, "These are the drones you need to fly first, so you don't end up crashing an expensive model into a TV tower." The left joystick controlled throttle and rotation and the right joystick operated the directional movement. If you pressed the left joystick in, it changed the speed, and pressing the right joystick would make the drone do flips. There were also small arrow buttons for "directional compensation."

It was all a lot of fun, though not entirely intuitive. We flew the Axis drones around, mostly outside. They were very fast, like little UFOs. The major drawback was that they needed to be charged every five minutes. Unlike the Parrot drones, which use batteries, these need to be charged via USB. So we flew one around for a few minutes, then charged it quickly while flying the other one around. They got integrated into my daily life by taking over my daily life completely.

When it was finally my turn to fly the Turbo-X drone, it launched and hovered. I flicked the left joystick. The drone flung into the air.

"That's going pretty high," Jennings said. Before I could stop it, the drone was over the rooftops of my neighborhood. Then it was over the tree line. Panicked, I flicked the joystick, which only flung it farther. We lost radio contact. Then we lost the drone. Inside the box, they'd written, in marker, "BE CAREFUL!" Now I knew why.

Jennings and the boys and I spent the next forty-five minutes searching the drainage culvert behind my house and the three houses on either side of mine. No luck. I snuck into the backyard of the creepy house two doors down from me, an act that in Texas runs you the risk of a twelve-gauge shell in your face. The Turbo-X had completely vanished. If only we had a drone that could help us find it.

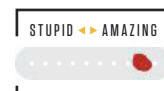
The following weekend, I had to drive down to Houston for an assignment. My friends Dakota and Allison, who used to be in my band, live there now. I brought the Rolling Spider drone, figuring we'd have some fun.

Dakota's life is always taking weird tech turns. I arrived at his house to see that he'd recently acquired a 1980s



NEW FACEBOOK BUTTONS

This fall, Mark Zuckerberg hinted at the possible introduction of a "dislike" button to Facebook. Soon after, the company tested six emoji icons (love, laughter, happiness, surprise, sadness, anger) called "reactions." This will be an amazing thing. It's great to be able to show your friend "I also don't like that your gerbil died," but it's also cathartic to be able to express another sentiment. Namely, "Tina, if you post one more picture of your brunch I'm going to unfriend you."



**LIGHTNING
ROUND!**

The three vacationing Americans who fought and disarmed



LexisNexis terminal, which he turns on just so he can see it say that it can't find its network. He also has two old black-and-white Sony TVs with little screens and long backs, which he's hooked up to his computer so when he has FaceTime business calls, the people he's talking to "look like Max Headroom." Drones weren't going to scare this guy.

We had a jolly time bashing the Spider drone into walls, but it got old. Then, at dinner, Dakota said, "Allison's parents got me a remote-control shark balloon for my birthday. We could set it up and have the drone battle it. It would make a great video."

Allison didn't look too excited about this idea. "I don't want to explain to my parents why you popped the shark balloon," she said, but then added, with a twinkle in her eye, "We do have other balloons. And a helium tank."

We blew up balloons and drew faces on them with markers. Then we tied them to chairs. Each of us took turns getting "kills" while the others filmed the drone. It was really exciting when we managed to ram the drone into the balloons, and it was even better when we were able to keep it upright when the balloons popped. But the real bonus moments came when we missed. Either the Spider brushed by the balloon with its wheels, leaving the balloon teetering but staggered, or, even better, it missed entirely, and went bouncing off walls, crashing to the floor with maximum drama. We could only do this for six minutes at a time before we had to recharge the batteries, and then we had to wait an hour and a half. If the charging time had been less, or if there had been an extra battery and remote charger like with the Bebop, we probably would have flown the Spider all night. It was that much fun.

"I can imagine one of these things following me around the house on wheels, telling me when it was time to call people or take the dog out for a walk," Dakota said. "They should make that drone."

The Spider had passed its audition.

There were two more drones left. The Ghost Aerial was from a Chinese company called Ehang. It has a pivoted support that is compatible with a GoPro camera. I arranged for shipping with a young woman who had a North Carolina number, though the Ghost came to me from Las Vegas by way of Hong Kong. The Ghost was a mysterious, unreliable pain in the butt. I later figured out that it's a poorly made knock-off of DJI's Phantom 3, the best drone I tested and the gold standard of the drone world. The Phantom comes with a built-in camera and comprehensible instructions. It's the product that will influence how we think about personal drones going forward. But on the day that my friend Tyler was available, all I had was the Ghost.

It was my biggest and most powerful drone at the time and was the one with the most filming capability. We intended to do something spectacular with it. Tyler, a movie and TV prop master and explosives expert, is a huge pyro. I've spent many delighted hours in his company blowing up pumpkins with fireworks. I told him to prepare a platform, and we'd film some spectacular explo-

sions. Maybe I should have taken the Ghost out of the box first.

It came with written instructions on how to fly it via an iPhone app and with a list of parts but with no instructions on how to put it together. By degrees, we figured it out. We assembled the camera, but we'd lost some screws, so Tyler had to connect the camera to the bottom using kitchen ties.

"I thought you were coming with a mechanic and a drone pilot," Tyler said, looking a bit annoyed. "I thought we'd be ready to go."

No such luck, buddy. After nearly an hour of frustrated wrangling, we snapped the battery into place. The Ghost hummed to life, with blinking red and blue lights. It was very cool and futuristic-looking, all white and stainless steel. Daylight was running short. We had to get it into the air quickly.

There was a little black box, which turned out to be a Wi-Fi apparatus that could simultaneously communicate with the Ghost and with my phone. But I couldn't find the antenna. I spent fifteen minutes trying to ram a piece of plastic landing gear into the antenna slot. That didn't work. I watched a video on the app, which showed a guy flying with the box under his phone, without the use of an antenna. But when I tried to get the app to connect, it just gave me incomprehensible calibration instructions. Then I looked at the owner's manual, which was also on the app, but it was in Chinese. Tyler, his girlfriend, Mollie, and I, all three relatively competent adults, could not for our lives figure out what to do next. The instructions just weren't clear. I pressed a link on the app called "Binding," and this appeared on the screen:

"Reminder BINDING... After success Then the plane electricity. STOP BINDING Cancel."

This instruction appeared over an area map. Of Guangdong, China. By now it was dark, and it was very clear that we weren't going to get the Ghost into the air. But I wanted to see fireworks.

So we left the drone on their kitchen table and drove a mile or so out to Tyler's friend's property. She lives on twenty acres of cow pasture, untroubled by light pollution. The drone would have loved it.

As we walked onto the property, a guy was tossing a gallon jug of kerosene onto a pile of pecan wood as three mastiffs and Mr. Magoo, the largest Boston terrier I've ever seen, ran around him in circles, snarfling madly. Within seconds, the pecan wood was a raging bonfire. So we sat out there on the grassland for a while, lighting off fireworks and drinking beer and then lighting off some more fireworks. Tyler had gotten ahold of some good ones. If only the Ghost drone had been able to film them. It would have gotten a real nice look at my daily life.

GENETICALLY MODIFIED BABIES

A new gene-manipulation technique called CRISPR uses an immune-system response discovered in bacteria to extract portions of DNA in cells and replace them with a desired combination. While the concept is not new, CRISPR is significantly faster and more cost-effective than previous methods. If we can somehow avoid the impulse to pick our kids' height and hair color in utero, CRISPR brings us much closer to being able to remove bad mutations, such as the one that causes cystic fibrosis.

STUPID < > AMAZING

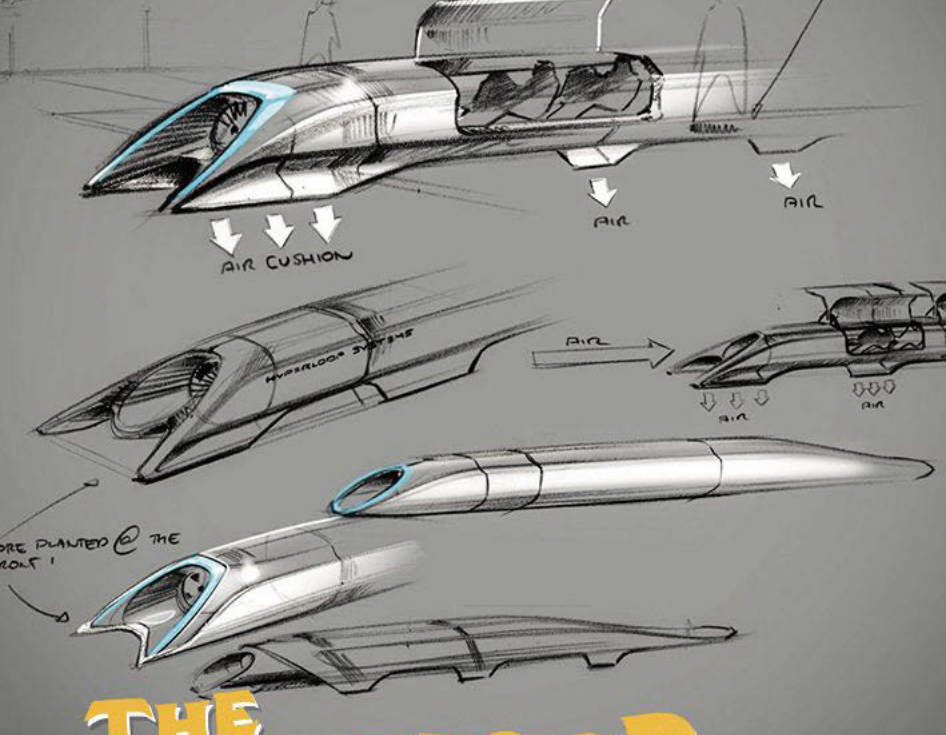


STUPID < > AMAZING



a terrorist on a French train. **AMAZING.**

PewDiePie, a YouTube sensation who records himself narrating scenes from video games. **STUPID.**

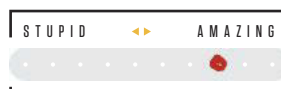


THE HYPERLOOP

of sound—two companies have emerged to develop it. Hyperloop Transportation Technologies crowdsources its labor, pays in equity, and has more information on its Facebook page than on its home page. The other, Hyperloop Technologies, has venture-capital funding, a former president of Cisco for a CEO, and a hip Los Angeles headquarters. We don't know which, if either, will be successful. But that doesn't matter. What's amazing about the Hyperloop is not actually the Hyperloop. It's how we address challenges like it.

The Hyperloop is a staggering proposal—a completely different form of human transportation that would connect cities in ways never before possible. But how will the capsules that riders sit in be slowed for stops and transfers without causing a pileup? Can g-forces be kept within reasonable limits? Will there be bathrooms? How hard will they be to use without peeing on yourself? If crowdsourcing, social media, and open-source technology can surmount these challenges and create large-scale physical infrastructure, we'll officially be in the next epoch, one in which the technologies we've spent the past thirty years trying to understand will have finally been harnessed.

Since 2013, when Elon Musk gave away his rough plans for the Hyperloop—a tube-based transportation system that would travel at nearly the speed



THE SELF-ASSEMBLING TABLE

Think of the ideating, engineering, and innovating that went into the design and technology behind this

amazing side table that assembles itself! This furniture—the first time anyone has thought to create such a thing!—was invented at the MIT Self-Assembly Lab. The malleable wood is sandwiched around a synthetic textile, and when the flat table is removed from the box, all you do is give it a slight pull and the tension of the fabric causes the

wood to snap into place! It must have been a staggering number of man-hours, and a huge amount of brainpower from some incredibly smart individuals. Just imagine if they had spent their efforts creating something the world actually needed!



THE LATEST SPECIAL EFFECTS



FURIOUS 7

After Paul Walker's death during the filming of *Furious 7*, director James Wan had to complete a movie without one of its stars. Using archival footage, Walker's brothers as body doubles, and advanced CGI software, Wan created a seamless stand-in—and a surprisingly touching homage. Twenty years from now, when a new generation watches this movie for the first time, unless it's revealed by the hologram information bubbles that will undoubtedly annotate life by then, no one will even know.

TERMINATOR: GENISYS

When Arnold Schwarzenegger debuted as Terminator, he was in his thirties. No matter how well he aged in the thirty-one years since, it would have been impossible for him to re-create his iconic nude scene for this year's *Terminator: Genisys*. Unfortunately the plot called for it, and audiences were subjected to a video-game-like rendering of young Arnold. In a movie in which computer software threatens humanity and time-traveling machines have German accents, the youthful Schwarzenegger was the hardest part to believe.



McDonald's new all-day breakfast menu. **AMAZING.**



The vapRwear hoodie with a "discreet e-cigarette built-in the drawstring." **STUPID.**

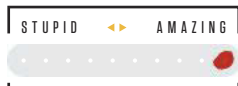


STUPID
OR
AMAZING?



INDUCTIVE CHARGING

The concept has been around since the Palm Pre—a smartphone that charged without cables, simply by being placed on an inductive surface. The Pre never found the success it deserved, but this year, inductive charging finally did. Two main options, Qi (pronounced “chi”) and Powermat, compete for dominance. Their surfaces are sold for home use or incorporated into Ikea furniture and the counters of Bay Area Starbucks. Some phones, like the Samsung Galaxy S6, have the technology built in. Others require a special case. But it’s worth it. Set your phone down on a charging pad and listen for a chirp. No dangling cables, no inserting the micro-USB plug upside down, no searching for a wall outlet. Inductive charging is slower than plugging in, but that doesn’t matter. Charging with inductive surfaces becomes so convenient that you can do it all the time. If a Starbucks near you offers tabletop chargers, you can buy an iced Red Eye and top off while you sip. Pretty soon we’ll look at these rat’s nests of cables we carry like the anachronism that they truly are.



WHISKEY AGED BY SCIENCE

(INSTEAD OF IN BARRELS)

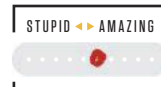
Cleveland Whiskey founder and CEO Tom Lix is not a patient man. He didn’t want to wait the years it takes to age a whiskey naturally—in charred oak barrels as subtle changes in pressure and temperature filter the alcohol through the wood’s pores, slowly absorbing its flavor and color. So he found a way to age his whiskey in one day.

Cleveland Whiskey is placed in oak barrels, but that’s only to meet the requirements necessary to call it bourbon. From there, the liquor and barrel wood are placed in a vacuum-sealed tank, where rapid pressure changes force the spirit through the wood’s pores. After twenty-four hours, Lix says, his whiskey can compete for complexity with those aged eight to ten years. The process also allows the two-year-old company to play with flavor. In the past, whiskey makers exclusively used oak barrels because they don’t leak. But neither do stainless-steel tanks, which allow Lix to experiment with woods such as black cherry, hickory, or sugar maple to add



Cleveland Whiskey founder Tom Lix at work in the lab.

different dimensions and taste. Cleveland Whiskeys aren’t quite as hearty as more traditional options and have a little more burn on your tongue, but the flavors drawn from the woods do make for an interesting drink. Besides, even if whiskey purists take issue with Lix’s product, it doesn’t matter to him. Lix considers Cleveland Whiskey a technology company, not a distillery.



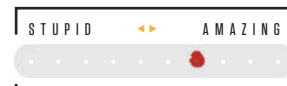
PERISCOPE

Were you one of the 4.4 million suckers who paid nearly \$100 to watch Mayweather-Pacquiao at home? Those no-punching swindlers each banked over \$100 million



from record pay-per-view sales. And it might’ve been more if not for Periscope, the live-streaming video app Twitter acquired earlier in the year. There were sixty-six confirmed Periscope streams of the fight—sixty-six people broadcasting the action (or lack of) to thousands of Twitter users, free. The streams were far from HD, and they didn’t last long. Twitter worked quickly to shut them down. But their simple existence showed the potential for amateur live streaming to disrupt

the out-of-control sporting event and concert industries. In the first half of 2015, North American concert prices averaged \$76.20, an all-time high. Periscope and other live-streaming apps like Meerkat may not be the perfect solution, but they do offer a way for consumers to fight back. Would have been nice if Mayweather or Pacquiao had done the same.



The Davek Alert, an umbrella with Bluetooth that tells you when you’ve left it behind. **AMAZING** (AND EXPENSIVE).

A *Mary Poppins* remake. **STUPID.**

THE NEW CAR TECHNOLOGY

Popular Mechanics automotive editor Ezra Dyer on a few things that confounded and delighted him this year.



HATCH SENSORS

The idea is that you're walking up to your car, arms full of groceries, and you deftly sweep a leg beneath the rear bumper, prompting the hatch to magically swing open. When the systems work, they're wonderful. Genius. But what's the worst place to mount a sensor of any kind? Probably right underneath the rear bumper. You can't see it, and every piece of oily crud on the road ends up glomming on in that general vicinity. So maybe you're a little off-target with your leg-wand, or maybe the sensor's covered with a Bubble Yum wrapper. The success rate for these things seems to be about 50 percent.



LANE-DEPARTURE WARNINGS

These systems use cameras to read lane markings and determine whether you're straying toward a ditch or oncoming traffic. It's a good idea, but in practice, the constant squawking becomes background noise, just another push notification in the Pac-Man soundtrack of your life.



KNOBLESS ENTERTAINMENT SYSTEMS

Perhaps if we all repeat the mantra often enough, it will come to pass: All cars should have one knob for the stereo volume and another to change the station, track, or source for whatever streaming ethereal cloud of code constitutes your preferred Bieber delivery system. Basic ergonomic decency aside, the touchscreen aesthetic does not belong in your car. Your phone, your tablet, your TV—you have enough sleek glass interfaces in your life. You need tactility. It's the difference between video poker and laying down a handful of cards on a felt table.

THE APPLE PENCIL

STUPID < > AMAZING

ent. It makes sense: The most valuable company on earth has more resources than a few engineers with a Kickstarter page—the guys making many of the styluses to this point. The difference between Apple and others is obvious if you try doodling with another brand's stylus. Because the stylus is trying to manipulate the screen to think it's a finger, the experience never feels like pen on paper. There's a delay between the movement of the tip across the screen and the mark that follows. Pencil, though, speaks directly to the iPad Pro, which means fast, precision tracking of the angle and pressure applied to the tip. While the usefulness doesn't seem immediately obvious to us (nor did it to Steve Jobs, who famously hated the accessory), Apple's always been good at selling us stuff we didn't know we wanted.



ULTRA PANAVISION 70

STUPID < > AMAZING

Quentin Tarantino is famous for breathing new life into things. Blaxploitation. Kung fu. John Travolta.

With his new film, *The Hateful Eight*, he'll do the same for Ultra Panavision 70. Most movies you see in theaters, whether they've been shot digitally or on 35-mm film, have an aspect ratio of 1.85:1 or 2.39:1—wider than the 16:9 of most wide-screen TVs. In the 1960s and '70s, some of cinema's greatest epics—2001: A Space Odyssey, Lawrence of Arabia—were shot on 70-mm for a 2.20:1 ratio. But because of the high cost, 70-mm narrative features are rare. Since 1992 only three have been shot entirely that way.

Tarantino originally planned to shoot *The Hateful Eight* in 70-mm. A couple of months before production was to start, the film's cinematographer, three-time Oscar winner Robert Richardson, was visiting Panavision's L.A. headquarters and stumbled across a shelf with some strange museum-piece lenses. This was Ultra Panavision 70, a patented anamorphic lens introduced in 1957 that achieved an astounding aspect ratio of 2.76:1. Only ten films had ever been shot using Ultra Panavision 70 before the lenses were left on that shelf in 1968—most famously *Ben-Hur*. Naturally, the chariot race was what Panavision screened for Tarantino to sell him on the idea. "We started off with the curtains open to [the width of] a typical movie," says vice president of marketing and technical support Jim Roudebush. "Once we rolled it, we opened the screen all the way out to the very far edges and said, 'This is what you're gonna get.' He was jumping up and down, whooping and hollering." The exact same lenses that shot that scene in *Ben-Hur* were used for *The Hateful Eight*. And, because of the way the glass aged, they look better than ever. "Over time," Roudebush says, "the coatings on the elements alter. The flaws give it character."

Since many theaters lack the technology to screen the 70-mm version of the film, a digital transfer, which Roudebush believes will lose none of its magnificence, opens January 8. Two weeks before, however, 70-mm prints will be released at fifty select theaters. It's worth the effort to find one.



Australian daredevil Robbie Maddison rigs his dirt bike so that he can use it to surf in Tahiti. **FINE, AMAZING.**

PM

Technology





Today's high school students are the first generation that won't remember life without smartphones, social media, texting—all the things that let us live our lives more alone and more together than humans ever have before.

What's that like for them?

By **Jacqueline Detwiler**
Photographs by **Christaan Felber**
Page

101

and the American Teenager

Brianna McMonagle, 15,
sophomore at Lawrence
Central High School in
Indianapolis, photographed
on September 15, 2015.



Down a locker-lined hallway at Lawrence Central High School in Indianapolis, Zac Felli, a junior, walks to his first class of the day. He wears tortoiseshell glasses and is built like he could hit a ball hard. He has enviable skin for a teenager, smooth as a suede jacket. Over one shoulder he carries a slim forest-green and tan messenger bag that would have been social suicide in 1997. But 1997 was the year Zac was born, so he wouldn't know anything about that.

A squat, taupe monolith flanked by parking lots, Lawrence Central smells like old brick and floor polish and grass. Its gleaming floors squeak if you move your foot a certain way. The school has existed on precisely this spot of land since 1963: maroon block letters over the door, tang of chlorine from the indoor pool. None of that has changed. Here's what has: After Zac turns the doorknob of Room 113 and takes his seat in Japanese III, he reaches into his shoulder bag, pushes aside his black iPhone 5S and Nintendo 3DS XL, and pulls out his Microsoft Surface Pro 3 tablet with purple detachable keyboard, which he props up on his desk using its kickstand. By touching a white and purple icon on his screen, he opens Microsoft OneNote, a program in which each of his classes is separated into digital journals and then into digital color-coded tabs for greater specificity. And then, without a piece of paper in sight and before an adult has said a word, he begins to learn.

Zac probably started developing memories around 1999, the year Napster upended the music industry by turning songs into sharable files that nobody owned. Or maybe in 2000, the year Google became *Google*. Regardless, he is part of the first generation of human beings who never really lived before the whole world was connected by pocket-sized electronic devices. These kids might never read a map or stop at a gas station to ask directions, nor have they ever seen their parents do so. They will never need to remember anyone's phone number.

Their late-night dorm-room arguments over whether Peyton or Eli Manning won more Super Bowl MVPs will never go unsettled for more than a few seconds. They may never have to buy a flashlight. Zac is one of the first teenagers in the history of teenagers whose adult personality will be shaped by which apps he uses, how frequently he texts, and whether he's on Facebook or Instagram or Twitter or Snapchat. Or whatever comes after Snapchat. Clicking like, clicking download, clicking buy, clicking send—each is an infinitesimal decision in the course of the modern American teenager's life. They do this, collectively, millions of times a minute. But together these tiny decisions make up an alarming percentage of their lives. This generation is the first for whom the freedom to express every impulse to the entire world is as easy as it used to be to open your mouth and talk to a friend.

How does all that change the monotony and joy and pain and wonder and turmoil that is the average teenager's life? What is it like?

Like many of the other 2,350 students at Lawrence Central, Zac knows computers better than even last year's graduating class did. The students here use them constantly—up to two and a half hours a day, according to Lawrence Central's principal, Rocco Valadez. This year is the first that Lawrence Central is one-to-one, which in educational speak means that every student on campus has been provided with a leased Chromebook laptop computer. Valadez considers Zac one of his beta testers, one of ten or so students the administration turns to for reports and opinions on how the technology is working. Zac, incidentally, asked if he could use his own Surface instead of a Chromebook. Because Zac is a high-level user, Valadez obliged. ("I'm a Surface guy," Zac says.)

You hear two opinions from experts on the topic of what happens when kids are perpetually exposed to technology. One: Constant multitasking makes teens work harder, reduces their focus, and screws up their sleep. Two: Using technology as a youth helps students adapt to a changing world in a way that will benefit them when they eventually have to live and work in it. Either of these might be true. More likely, they both are. But it is certainly the case that these kids are different—fundamentally and permanently different—from previous generations in ways that are sometimes surreal, as if you'd walked into a room where everyone is eating with his feet.

An example: It's the penultimate week of classes at Lawrence Central, and the pressure has been released from campus like a football gone flat. The instructor of Japanese III, at the moment ensconced behind a computer monitor that is reflected in his glasses, switches on the announcements. The

(1) The college classroom in 2015. This one is at Indiana University. (2) Brianna McMonagle is allowed to use Instagram but not Snapchat. (3) As one of Lawrence Central High's "high-level users," junior Zac Felli, in the blue shirt, is permitted by the administration to use a Microsoft Surface instead of the Chromebooks most students use. (4) Anthony Thomas helping another student log in to his computer in study hall. (5) Leah Arenz, on the right, looks at One Direction photos on Tumblr.

American tradition in this situation—end of school, little work to do, teacher preoccupied—is that the students would be passing notes, flirting, gossiping, roughhousing. Needing to be *shushed*. Instead, a boy to Zac's left watches anime. A girl in the front row clicks on YouTube. Zac is clearing space on his computer's hard drive, using a program called WinDirStat that looks like a boring version of Candy Crush—definitely, quietly, he moves small colored squares around to clean up the drive. Green, red, blue, purple. (When he types, he types evenly—none of that hinky freeze-pause-backspace thing that every adult with a hint of self-consciousness does when typing in front of anyone else.) Above a ziggurat of loaner Chromebooks at the front of the classroom hangs what's called a Promethean board, a panel that looks like a digital tablet the size of a Shetland pony. On the Promethean board, the day's announcements play, including a news segment on a London School of Economics study. The anchor begins: "Test scores increase by more than 6 percent at schools that ban smartphones . . ." At this the students in Japanese III—absorbed in private computational fiddling, phones out on their desks like pencil cases—let forth a chorus of snorts.

Otherwise, Room 113 is eerily quiet.

LEAH

"The primary motive that teenagers have when they're screwing around online is to connect with somebody else," says Larry Rosen, former psychology chair at California State University, Dominguez Hills, and author of *Rewired*, a book about how technology has changed the lives of the next generation. Lawrence Central senior Leah Arenz does this every day. Also every night. Sometimes even when she ought to be sleeping.

Leah, hair slicked back under a headband, is editor in chief of the school newspaper, often staying in the journalism classroom until midnight to close an issue. She's eighth in her class. When she speaks to you, she makes quick eye contact, and then just as quickly breaks it. Unless you ask her about the band One Direction. Then she becomes someone different altogether.

Leah has a secret Tumblr page she posts to twenty-five to fifty times a day. It's how she



Anthony watches videos of Olympic discus throwers on YouTube. Like many students, he keeps no books in his locker. Just a bottle of cologne.



interacts with what she calls the Fandom, some 25 million acolytes of One Direction who repost, rehash, and relive the band's activities like a swarm of unpaid TMZ employees. Her friends at school do not know the address of her page—they don't even know about this other life at all. "I don't think they would understand or appreciate it the way people in the Fandom do," she says.

When Leah talks about the Fandom, she engages like a drivetrain, leans forward—almost out of her chair—and speaks so quickly you'd swear she was on some new drug. She cracks jokes. Her eyes meet yours. When she blogs, at her dual-screen laptop-monitor setup under a green-shuttered window, she holds her face inches away from her monitor, tabbing between Web pages so quickly she must be selecting photos using only some primordial subconscious boy sense. You get the idea, talking to her, that her Tumblr is more than a hobby. More like an Internet breathing tube. A silicon lung. "I'm weird," she says. "I like 1D. But there are millions of people online who like 1D like me."

For someone like Leah, who built her first website at fifteen and seems uninterested in climbing the capricious social hierarchy that exists in every high school, the community of the One Direction Fandom offers an entirely alternate social structure. It is a universe in which her skills at iMovie, GIF creation,

and news collection, paired with the scope and anonymity inherent to the Web, render her an authority on teenage problems both minor and major. "A girl recently contacted me and said that her friend was dealing with social anxiety. She didn't know how to talk to her about it. Later tonight I'm going to think out a carefully worded answer," Leah says.

In this universe, she has great power. Having dinner with her father in an Applebee's near her home, Leah describes how, a few weeks ago, the Fandom was infuriated when one of its favorite One Direction songs, "No Control," had not been chosen as a single by the record label. The Fandom loved the song and was frustrated they weren't being heard, a familiar refrain among teenagers. And so Leah, along with thousands of other Directioners, as they're called, campaigned radio stations to demand airplay. Leah herself tweeted and blogged and reblogged incessantly, staying up at her computer until the stars emerged and receded over her home's suburban lawn. At 2 a.m., she and many, many others favorited tweets to a radio station in New Zealand until finally it played the forgotten song eleven times in a row.

By the time the band began the American leg of its tour, One Direction was playing "No Control" at every show, and Louis Tomlinson, Leah's favorite band member, thanked the teens for their input onstage. It's as if

Beatlemania junkies in 1966 had had the ability to demand "Rain" be given as much radio time as "Paperback Writer," and John Lennon thought to tell everyone what a good idea that was. The fan-celebrity relationship has been so radically transformed that even sending reams of obsessive fan mail seems impersonal. Leah's mom, in fact, was one of the original devotees of *X-Files* fan fiction in the 1990s, but she never had the opportunity to achieve the kind of connection her daughter can. As David Weinberger, senior researcher at the Berkman Center for Internet & Society at Harvard University, explains, "You're not simply a consumer anymore. By connecting with other people, you become a participant in the life of the band."

In the Applebee's, Mark Arenz is shocked enough by Leah's story to take a fatherly feint at her sleep habits. "Is *that* what you were doing that late?" he says, then immediately relents. How much of an argument can a parent level against a teenage girl with a 4.7 GPA whose worst offense is staying up late to crush on a boy she'll never meet?

"Imagine what you guys could do in the Middle East," he says.

THE TEACHERS

English teacher Paige Wyatt is one of Lawrence Central High School's eCoaches, a group of teachers who educate other



But then sometimes they watch movies—in *class*. Sometimes they take selfies—in *the bathroom*. Sometimes a student will send a teacher a rude message on an anonymous Web platform, or post his own phone number and home address on Facebook.

It's now the end of the year, and all the Chromebooks have been collected for the summer. "Our study halls are huge—there are forty to seventy kids and one faculty member," Wyatt says. "Normally they just plug in their headphones and keep themselves busy on their Chromebook, but now that we've collected most of them, we're worried that they'll be off-the-wall crazy without something to keep them busy."

ZAC

With the school year nearly concluded and final concerts wrapped a week ago, there is nothing to do today in band class. The band director barely makes an appearance. Pairs of students flop all over the classroom

one so together that they're actually all apart.

In the band room, if you're standing at the conductor's podium, Zac is sitting on the left side of the risers, about where you'd usually find a pack of timpanists. He's taking a break, playing a video game he found on the blog of a computer programmer he follows. He discovers a lot of entertainment this way—down in the lightless caves of the Internet known only to young people. He has Facebook, Instagram, and Google accounts and four Tumblr blogs. He follows a goateed YouTube comedian named JonTron who reviews videos and games. And Reddit. "I don't know how much time I've wasted on Reddit," he says.

Behind Zac, on the floor, sits the group that 1997 Zac, if he existed, might have wanted to join. It is mixed—four boys and two girls. The girls are cute and friendly. The boys affect cool nonchalance. They talk about who's got a crush on whom and whether they should all go to a JV basketball game together. One of the girls tries to convince one of the boys

IN CLASS, EARBUDS ARE MORE COMMON THAN FULL-SIZED HEADPHONES, BECAUSE YOU CAN LISTEN TO MUSIC AND STILL HEAR THE TEACHER—ONE BUD IN, ONE BUD OUT.

teachers about Chromebooks, passwords, Promethean boards, and wise and unwise uses of YouTube. At twenty-seven, she understands much of what the students do. And when she doesn't, she asks.

Take the rules of Instagram. Wyatt just learned them today in the honors English class she teaches. "I was ribbing on this one boy a little bit. He was on Instagram and I asked him, 'What the heck is Instagram?' He said, 'I was just liking pictures. I can't be a ghost.' I said, 'What do you mean, a ghost?'"

Then the whole class chimed in. They explained the rules to Wyatt: You have to have more followers than people you follow. You have to comment on and like people's stuff. Otherwise you're a ghost. And being a ghost is bad.

A campus firewall called Lightspeed is supposed to block Instagram. But obviously, somehow, the students are using it. Because here's something about high school that will never change: The kids live by their own codes, and if adults make rules, the kids will find ways to break them.

"We talk to the kids about responsible use of technology. We talk about credible sources. We talk about being smart," Wyatt says. "A lot of them seem to know, 'Well, you'd never post *that* online. That's stupid.' But a lot of them also don't know. And a lot of them don't care."

For the most part, kids behave themselves.

on the risers, sharing earbuds attached to single phones. One girl, wearing pajamas, has curled up around a music stand like a cocktail shrimp and gone to sleep.

Devoid of a responsible adult, this class period has become one of those interstitial moments in teenage life, a rare, vital time when regulation of the adolescent schedule is up to the teen himself. To emerge whole after teenagerhood, one must craft a (hopefully) charismatic personality out of the preferences and skills discovered during times like these. Playing this guitar. Kicking that soccer ball. Reading a book on the history of Asia during the Tang Dynasty. Eventually, the teen becomes a complete person with well-defined interests who then locates other complete people to keep as friends. This has not changed, only now the potential interests to explore are limitless, and the resulting communities so far-flung and socially disconnected that "friends" are not friends the same way they used to be. A "like" is not really a like. The teens' brains move just as quickly as teenage brains have always moved, constructing real human personalities, managing them, reaching out to meet others who might feel the same way or want the same things. Only, and here's the part that starts to seem very strange—they do all this virtually. Sitting next to friends, staring at screens, waiting for the return on investment. Every-

to put on some of her makeup.

"Absolutely not," he says.

"It's only going to be us that sees it!"

"You sound like when boys ask for nudes," he says.

"We're not even going to take pictures!"

Zac pays no attention to this, not even when the group names a specific couple that has been "smashing"—2015-speak for having sex—for months. Neither does Zac notice the boys reading rude jokes from a cellphone propped on a music stand. He is deep in an entertainment rabbit hole of his choosing, and he has no need to amend his interests to fit in with the social noise around him.

On the one hand, this is an enviable turn of events for high schoolers. There's no dulling the edges of young personalities in an effort to be popular. "If you have an interest in coral reefs or six-string bass guitars or whatever, you can now find a set of people who are just as interested, and you can explore any topic to whatever depth you want," says Weinberger, the researcher from Harvard. What a great time to be alive!

But the converse is also true. "If I'm talking to a stranger and I mention some smaller, lesser-known video game, or I say, 'Hey, have you heard of this band?' chances are they haven't heard of it," Zac says. "I think the only thing that I can truly maybe relate to someone with is something iconic, like *Finding*

Nemo or something.” There are fewer true shared experiences—fewer TV shows that everyone watches, fewer bands that everyone knows. There will be no *I Love the 2010s* version of the VH1 series *I Love the ’80s* because there won’t be enough nostalgia for communal culture to make such a thing worthwhile. Following this observation to its logical conclusion is fearsome: an entire generation that can go online and find legions of humans (user names, really) with similar interests but that barely knows how to connect to one another in the physical world. Friends, sitting around screens, not talking.

Zac’s Surface sits on his knees, his cellphone on his thigh. He has moved on to playing a fighting game—Super Smash Bros.—on his Nintendo 3DS XL, which he holds in front of his face. Three gadgets vie for his attention within his immediate field of vision. A green message, sent through Japanese texting app Line, appears on the Surface Pro. He places the 3DS XL next to his phone while he responds in silence.

Lately, Zac has become concerned about his attention. He’s been drifting off in class more than usual, daydreaming, tapping on things. When he brought his worries to his parents, they offered to make him an appointment to get tested for ADHD in the summer, after the school year was over. No point adding stress to finals week, they said.

Next to Zac, Chance Williams, a friend, plays a video game for a minute but then abruptly shoves his computer away and tries to interest Zac in a real-life game involving note cards. Chance is largish, spiky-haired, full of kinetic energy.

“I’ve got an invite to Emma’s graduation party,” he says.

Zac doesn’t respond.

ANTHONY

Before the other kids file into Mr. Smith’s Introduction to Engineering Design class, a science and technology course Lawrence Central offers in conjunction with a nearby technical center, Anthony Thomas is in his seat, looking around. “Some of the kids in this class are bad,” he says.

Anthony is such a good kid that everyone at Lawrence Central describes him in exactly that way. “What a good kid,” his teachers say. And he *is*. Anthony plays linebacker for the football team, where he displays the loping, easy athleticism of a large cat. He holds the door open for strangers. He has known he wanted to be a mechanical engineer since he was thirteen years old, when, after spending the day fixing things at his grandma and granddad’s house, he searched “Hands-on careers” on Google and it sent back “engineering.” He is mature, he is focused, and he is sixteen.

It’s the last period of the day, and the other students in engineering design tumble into the classroom like a passel of river otters—flopping into chairs, whipping out stickered iPhones, unraveling earbuds. The earbuds are more common than full-sized headphones, Anthony tells me, because you can listen to music and still hear the teacher talk—one bud in, one bud out.

Anthony does not wear earbuds today. Neither does he look at his phone, even though that too is allowed. Today, the class is supposed to turn in a final assignment: Use the design software Autodesk Inventor to outline and laser-cut parts for a cellphone station that can hold at least five unique accessories. Playing with apps while trying to do this would only distract him, Anthony says. It’s an obvious point but not one you expect from a high school student in 2015.

Once, Anthony says, he received a message on his phone that he felt he had to answer in class. But then he wandered from the messages app to the Colts football app to Instagram to playing Madden football. In class! When his teacher announced that it was time for the students to start on an assigned project, Anthony had to ask someone next to him what they were supposed to be doing. He was disappointed in himself for losing focus. “I didn’t like that,” he says.

Anthony now avoids distraction by keeping his iPhone in his bag. He knows that if he clicks its lone, enticing button, he’ll slide down the rails to the carnival of games it

contains. On his desktop monitor he operates only in Autodesk, not clicking on any of the other myriad sites quietly awaiting his attention below the still face of his design template.

You look at Anthony, and you see the way the system is supposed to work. The way Principal Valadez intends for it to work. And then you look at some of the other kids and you worry. Five of the other nine students are watching YouTube videos of a self-driving Mercedes-Benz. They debate the merits of rappers Gucci Mane and Soulja Boy. One makes a rude comment about a woman in a video on his screen.

At this, Anthony bristles. “Ay, man,” he shouts with a disappointed shake of his head that not only actually silences the other kids but draws not a single snarky response. He looks around the classroom: “They don’t even work,” he whispers.

Will they fail?

“Yeah!” he says, with the incredulity of someone who can’t imagine a person allowing such a thing to happen.

Anthony walks to the lab down the hall to cut out the pieces of his cellphone holder. Back in the classroom, another student—one of the five involved in the rude YouTube comment debacle—gets into a verbal altercation with the teacher, who, exasperated, throws him out of class.

“Of course there were goofballs ten years ago, but I don’t think the ratio was as high,” the teacher, Jeff Smith, says afterward. He’s taught in this district for twenty-four years. “A video game, you get killed or whatever, you push reset. You can reset a thousand times. For some of this stuff, there’s no reset button, and when something doesn’t work, they’re over it.”

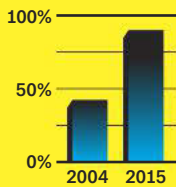
Anthony stays late to use the laser-cutter even though the bell has rung, eyes shining as he watches the pieces of his project materializing out of a blank sheet of cardboard. He stands with his hands clasped behind his back, smiling. “I probably shouldn’t be this excited,” he says. And then he runs off to catch his bus. He doesn’t bother to stop at his locker. What would he need to keep in there?

THE DIGITAL ADOLESCENT

Today’s high school experience is being largely lived, communicated, and recorded on electronic devices.

24%

of teens are online “almost constantly.”



Percentage of teens who have or have access to a cellphone.

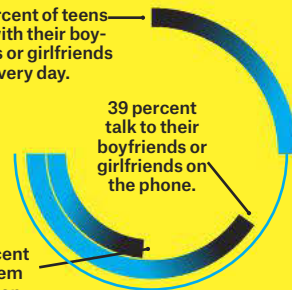
71%

of American teens are on Facebook. Half use Instagram and 4 in 10 use Snapchat.

72 percent of teens text with their boyfriends or girlfriends every day.

39 percent talk to their boyfriends or girlfriends on the phone.

21 percent see them in person.



BRIANNA

"We were the mean parents," Tabitha McMonagle says, stroking her son's hair while he presses his face against her hip. Her daughter, Brianna, wasn't allowed to have a phone in elementary school, which put her in the minority. She didn't get one until the beginning of seventh grade. She wanted a phone, but Tabitha and her husband said no. Not until she had a reason, such as after-school sports, to make it necessary, they said.

Now, at fifteen, Bri has a smartphone, a powder-blue iPhone 5c in a LifeProof case with a yellow softball sticker on the back. She wants Snapchat, but her parents have put their foot down about that. "Too many kids make stupid decisions with apps like Snapchat," her mom says. "That's a quick picture that you think is gone as soon as you send it. But the reality is, it isn't gone. I can take a screen shot of Snapchat. I don't think my children are going to send inappropriate images necessarily, but a lot of children have."

Bri has Instagram now, but she didn't for a long time. That was a battle. "She asked for it repeatedly, and I didn't see the purpose," Tabitha says. "You have a phone! You can text your friends, you can call them."

In the end, Tabitha joined Instagram first and did a search for all her kids. She found one—Bri's older half-brother. "He had everything in there—his school, what grade he was in, his phone number," Tabitha says. "One day when he was visiting—he lives in another house—I pulled up the sex-offender map. I said, 'These are just the ones we know about. They can find you.' Well, that worked. He was like, 'How do I get all this off here?'"

Tabitha has concerns about giving the vast capabilities of the Internet to people whose brains aren't fully developed. "We're in a climate right now where there is so little tolerance for children's mistakes," she says. "I understand that teenagers are children. It's important to make them wait until they're mature enough to understand that there are some risks involved with putting that much of your own information out there."

If you don't, you end up with problems



like Zac Felli's: He created his first Facebook account at twelve and included his cellphone number and email addresses. "I wanted people to be able to contact me," he says. "I'm still trying to get rid of the aftermath of ad lists and servers that I've been put on. I still get spam every day. Oh my gosh. It's ridiculous."

At her softball games, where she plays shortstop, Bri keeps her cellphone in her bag. Her teammates do too. Sports are no time for distractions. The resulting scene is as peaceful as a sepia-toned photo, and about as ancient: Bri's father crouches behind the umpire, shooting photos with a real camera. A Canon. What the camera sees: Bri's hay-yellow braid flopped over her shoulder, a spray of freckles across her nose, a permanent blush from all the sun. The girls, clay-dusted in uniform, cheer for their teammates against the fence, no phones anywhere. It could be 1997, another era completely.

Except on the sideline, where Bri's tow-headed twin brothers, bored half into a stupor, look at exceptionally stupid ifunny.com photos on their phones. Nearby, a baby tries to grab an iPhone until a toddler brings her a flower instead. The baby tries to eat it.

ZAC, SUMMER

The hardest ADHD test, in Zac's opinion, was the one with the stars. First, a technician strapped a motion sensor to Zac's forehead. Then Zac had to sit in front of a computer for twenty minutes staring at a white screen. Black stars with different amounts of points appeared every few seconds. The instructions: Click the space bar if you see a five-pointed star. Don't click it if you don't. "It was so hard," Zac says. "One: To keep paying attention. Two: To sit down and do nothing else for twenty whole minutes."

Many experts, Larry Rosen among them, will tell you that teens' constant multitasking is actually just task-switching, moving back and forth between different activities at a breakneck pace. Through multitasking, teens spend about seven and a half hours a day consuming about ten and three-quarter

hours' worth of media. Every one of the students in this story, all of them good kids, sometimes receded into an alternate universe mid-conversation. They don't seem always capable of—or maybe interested in—doing a single thing for a long time. For example: the stars.

To many adults, this sounds calamitous. A generation of task-switchers who can't think deeply about anything. We're all doomed! But then ask teenagers if they feel drained by the relentless demands of the Internet, and they'll tell you they don't. "I wouldn't say I feel overwhelmed with all the technology, especially because my generation grew up utilizing it," Zac says. "Overwhelmed? No," Anthony says. "I was born with technology around." And so what if teens are multitasking all the time? We're not any better at it than they are, and the Internet isn't going away. Maybe they do get access to the entire world before they're ready. Can we expect them to choose the opposite?

In the short story "All Summer in a Day," by the science-fiction writer Ray Bradbury, a young girl from Earth named Margot has moved to Venus. There she finds that it rains constantly, the sun emerging from behind the clouds for only a few hours on a single day every seven years. Margot remembers sunlight from her time on Earth. She misses its heat and light. The other children, the children of Venus, who have never experienced anything but the incessant pinging of droplets, aren't bothered by the rain at all.

The test results say that Zac has mild ADHD. But he also has a 4.1 GPA, talks to his girlfriend every day, and can play eight instruments and compose music and speak Japanese. Maybe his brain is a little scrambled, as the test results claim. Or maybe, from the moment he was born, he's been existing under an unremitting squall of technology, living twice the life in half the time, trying to make the best decisions he can with the tools he's got.

How on earth would he know the difference?

300

A teen Facebook user's median number of friends.

33%

are friends with people they have not met in person.



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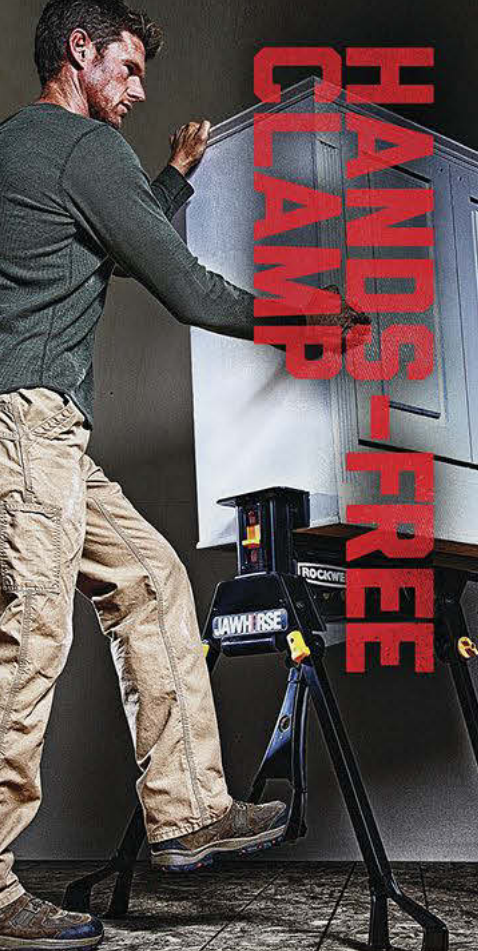
JERRY'S PINBALL MACHINE

The broken pinball machine in my fiancée's parents' basement has been in the family longer than I have. Despite zero pinball-repair experience, I decided to try to fix it.

BY PETER MARTIN

For years, only the left flipper worked. So for years, Jerry played with only the left flipper. In the basement of his family's home in rural Connecticut, the flashes of white and yellow reflected off the lenses of his glasses as he stood intently over his Sharpshooter pinball machine, sometimes for hours. More than a decade earlier, with both flippers operational, the entire family—three kids and even his wife, Cynthia, who generally doesn't have an interest in that sort of thing but is drawn to any kind of familial excitement—would be downstairs with him, peering over the edge to watch or anxiously waiting in line for Jerry's ball to drop between the flippers, the loud *clunk* and seemingly endless chiming of the scoreboard signaling the start of their turn. But kids don't have the patience for one-flipper pinball, so when the right flipper went out, the machine turned from a family thing to a Jerry thing. Eventually it became something for no one at all—a relic in the basement graveyard, across from the ping-pong table and next to the cast-off couch, an electronic putting green rolled up haphazardly beneath it.





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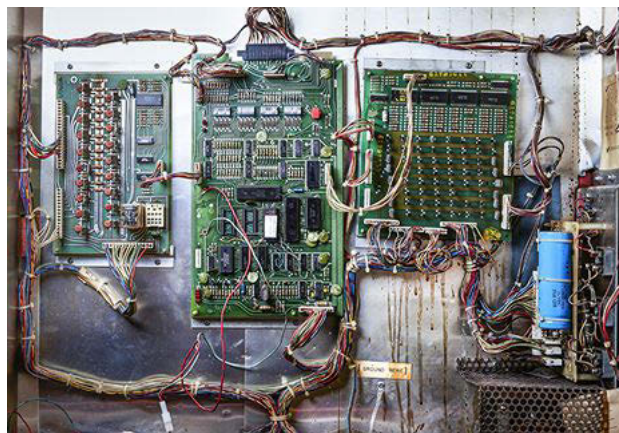
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Clockwise from above: Stripped screw holes were fixed by adding nuts below the surface; searching for a dropped part; and the MPU. The streaks running down the bottom right are likely from a beer spilled decades ago.



➔ Jerry is my soon-to-be father-in-law.

In the six years I've known him, the Sharpshooter game, which he bought secondhand from a bar supplier in the '90s, was mentioned only in occasional stories, or when his daughters kicked around the familiar idea of having it fixed and surprising him on his birthday. No matter how many times I walked by the machine to find a bottle of wine or get something from his toolbox, it never occurred to me to try to fix it. The hot tub on the back porch was broken, too, and I wasn't about to open up the panel and start working on that.

In that house, I always try to do plenty. As much as they've welcomed me, I'll always have the urge to earn it. The easiest way for me to do that is by fixing things. And in this family, those can be really little things: I get Bob Vila comparisons for resetting a sliding screen door on its tracks. Sometimes when we come up for a weekend visit, a small to-do list will be delicately suggested. I love it. Their faith in me is misplaced, considering my actual abilities, but I consider it a sign of affection.

One bored afternoon, when I discovered how easy it was to open up the machine and access the playing surface, I decided to see what I could do. I would work on weekends, setting a goal to finish by Labor Day, six weeks away. I mentioned my plan to Jerry, to get his blessing in case something went terribly wrong. His enthusiasm surprised me—and

put on the pressure: "Are you kidding?" he said. "You'd go into the prospective-son-in-law hall of fame!" He even brought up the benefits it would mean for his two young granddaughters, giving me two generations of family to possibly disappoint. He remembered the nonworking flipper being caused by a broken part. A repair person had taken it to find a replacement and then disappeared.

I did a little online research and learned that the designer of the game was a man named Roger Sharpe. He's the cowboy whose legs are draped with fawning barmaids on the backbox of the machine. He's also the reason there is pinball in New York.

In the early 1940s, pinball was in trouble. This was partly due to the mob's involvement, but more to the outcry of a small and loud group of uptight citizens who considered pinball a form of gambling and a vice that was as appealing to children as it was ruinous. New York's mayor, Fiorello La Guardia, agreed with them, and in 1942 he oversaw a citywide ban, even taking a sledgehammer to a few machines himself. Three decades later, Sharpe was called upon to prove that the game was one of skill, not luck. He played in front of the New York City Council, who remained unconvinced—until he called his final shot like an arcade Babe Ruth, sending his ball straight up and into a channel at the top of the board.

As it turns out, Sharpe isn't just good at pinball. He's also gracious to strangers who blindly email him for help. When I tracked him down, Sharpe put me in touch with

PINBALL MACHINE

Jeremy Fleitz, a software engineer and pinball collector who immediately agreed to help. He refused to let me pay him. The idea of resurrecting an old machine was enough.

The first weekend of work was dedicated to diagnosis. After enlisting my future brother-in-law Dan for technical and moral support, I downloaded the schematics and manual, thoroughly overwhelmed myself, and instead followed a simple set of instructions from Jeremy. When you plugged it in, the Sharpshooter would power on, making a staticky *rat-a-tat* meant to resemble gunfire. That was it. None of the buttons worked. Jeremy had me open up the back-box, where most of the electronics are stored. There I tested the five main fuses and the power supply, which included a 120-volt transformer that scared me enough to kiss my fiancée, Meryl, goodbye, just in case, before touching both ends with a multimeter. That worked, and we got continuity on the fuses, so it was on to the pinball machine's brain, the MPU.

When I powered up the machine, instead of flashing six times, as Jeremy hoped it would, the LED on the MPU stayed steady, a clear sign that it was toast. Jeremy blamed the NiCd battery attached to the side, which most collectors remove immediately (the batteries have been known to leak and damage the boards) and replace with a battery holder away from the MPU that takes replaceable AAs. One end of the battery was covered in brittle blue foam. It had completely disintegrated the dime-sized capacitor below it. With my limited electrical knowledge, it wasn't worth trying to fix. Jeremy, who swore troubleshooting the board would be fun for him, offered to trade us for one he'd already reconfigured.

A week later, Jeremy's board arrived. I labeled and removed the connectors from the old board, took pictures for mapping purposes, and swapped it out. My nerves were high when I plugged the machine back in. If any connector was out of place, I could fry another MPU. I didn't want Jerry to be around to see such an early failure, so I did this part late at night. After the gunfire, a new set of sounds emanated from the speakers. Even better, the START GAME button worked, and I could play a one-flipper game.

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PROJECT

lem, we continued testing the next morning. Like many pinball machines, Sharpshooter has an ingenious self-diagnostic system, activated by pushing a button behind the coin slot 12 times. That lights up all of the bulbs on the playing field so you can see what's burned out. We replaced four and tightened four others. Hit the button again, and it runs every number through the digital display. They all worked. Hit it again, and it fires every solenoid. We heard 17 loud *thunks*, then nothing for the 18th, which controls the right flipper. A final push tests every switch—the electronic connections that are held open or closed until the push of a button or whack of a pinball completes or breaks the circuit. An error code popped up on the display that corresponded to one of the drop targets on the playfield. Not surprisingly, that target had been sticking the night before. For the first time, without Jeremy holding my hand, things were actually making sense.

Unlike much of the electronics, the mechanical components and issues were visually clear and easier to resolve. Play surfaces of pinball machines can be propped up like car hoods for repair. (Just remember to take the pinball out first, a step I forgot many times over the next couple of weeks.) Underneath, you can follow the wiring from the MPU through the system. You can see how simple drop gates are activated, how electrical connections are made upon impact with the ball. With that faulty switch, we could see that the sensor was trapped behind the rubber impact band that wrapped around a triangular housing. All we had to do was unhook it.

Any confidence we gained didn't last long. Underneath the broken right flipper, a solenoid was hanging, unaffixed to the surface, and the plunger that runs through it lay on the bottom of the cabinet. With the left flipper for reference, I reassembled everything on the right-hand side. That's when we figured out the part the repairwoman had disappeared with: There was no bracket to hold the solenoid in. Luckily, I had Jeremy, and Jeremy had extras. He sent along a replacement bracket, called a coil stop, that I would install the next weekend. He also emailed me a list of other parts that I needed to buy from the pinball site marcospec.com. The shopping list:

A rubber-band kit. Thick protective bands that wrap around the flippers and most of the other surfaces the ball comes in contact with. They make the playing surface look a lot less dingy, since they're bright white when new, as opposed to cracked and gray.

HOW TO BE BETTER AT PINBALL

BY JOSH SHARPE, SON OF ROGER,
AND ONE OF THE TOP-RANKED
PINBALLERS IN THE WORLD



Ease off the flippers. This isn't *Mortal Kombat*. Don't button mash. Use one flipper at a time and only when you want to hit the ball.



Cradle the ball. Trap the ball in the angle of the upright flipper and assess the playfield for your desired hit, turning a defensive game into an offensive one.



Don't fear the tilt sensor. It takes a big hit for TILT to turn off the machine. Newer machines give two warnings. Bump and shake the cabinet to move the ball where you want it to go.

Flipper coils. The solenoid on the right flipper was bad, and even though the left one still worked, since it looked a little browned, we decided to replace them both.

Plunger and link. The metal rods that run through the solenoid and move the flipper. We replaced both to make them match.

Replacement bulbs. For the broken lights.

Pinball. Even if a ball looks good, Jeremy said, it's often roughed up from all of the contact in the game. The result is like running sandpaper over your playing surface. Besides, they're only a dollar. And shiny.

While we waited for the parts to arrive, Dan and I attempted to restore the sheen the game must have held when it was first played in 1979. Jeremy warned us against water-based products, which can cause the wood grain to lift, and suggested Novus plastic polish, magic erasers, rubbing alcohol, and Carnauba car wax. With every step, Dan and I looked at each other, a little baffled and disappointed, before agreeing that the next step would be the one to really make it shine. Then we ran out of steps. The playing surface definitely looks better, but the problem wasn't dirt. It was wear on the table, which we have chosen to think of as a classic patina.

A week later, on my own this time, everything but the coils was easy to install. Those had to be soldered on, and I had less experience soldering than I did repairing pinball machines. Over the next week, after wasting more time at work than I should have watching YouTube videos, I was convinced it was something I could handle. I bought an inexpensive Weller gun at the hardware store and quickly learned to hate soldering. The videos I

PINBALL MACHINE

watched were of work done on flat surfaces and with confident fingers. My job was propped at head height and had to be rigged with a clip to stay even remotely stable. Plus, my hands were shaking. It's a good thing for safety glasses, because I learned that hot solder can really spring off a thick wire. Luckily it cools on its way to you in the air, and you hear only a little *tink* as it ricochets to the floor and you start over. My soldering job may not have been beautiful, but it was effective: I turned on the machine and played a game. With both flippers.

There were still issues, of course. The right flipper doesn't quite have the power of the left—maybe 80 percent. Jeremy offered a few new wiring suggestions, but they involved soldering and I figured no one would be crushed by the disparity, so I decided to save that fix for later. Then, after a few games, the left flipper started to droop. A little Loctite on the screw that held it in place worked great. Finally, the fun part: It was time to break the news to Jerry. I went upstairs and, in what I thought was a casual way, asked if he'd come check something out in the basement with me. Cynthia and Meryl followed us downstairs. Not that there was any pressure.

Jerry was smiling before he even saw the pinball machine. That smile got bigger when he flipped the power switch and the scoreboard lit up. When he started a game—with both flippers!—the smile may have even eclipsed the one he'd had when I asked to marry his daughter. We stayed down there for a couple of hours that night, the four of us battling one another in mini-tournaments as Cynthia took pictures and talked about what great memories the game brought back. She lit up every time the ball banged around loudly in the bumpers, saying how much she loved when it did that. The rest of us were loving it, too, getting competitive and starting a new game immediately after one would finish. More than a few times, Jerry's arms were in the air in celebration. He high-fived his wife for being the first of us to get over 100,000 points. There may have even been some smack talk. Now that the pinball mission was done, I was surprised to find that I already had a new project. Or at least a new goal: I had to win. PM



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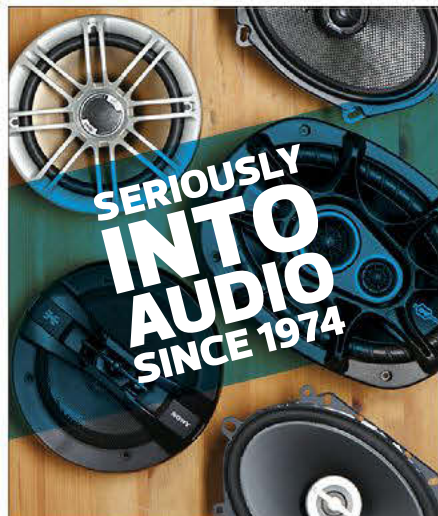
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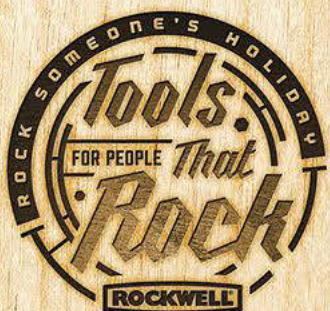
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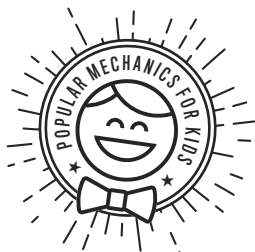


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STEERABLE SLED

A project to build with your children.

DESIGNED BY JAMES SCHADEWALD

Shopping List

QTY	DESCRIPTION
1	¾" x 1½" x 8' PVC trim board
2	2" x 4" x 8' select stud
1	¾" x 3½" carriage bolt and nut
3	¾" galvanized steel washers
1	1-lb box No. 10 2½" deck screws
1	6' piece of ¾" nylon rope
1	½" x 8" x 12" poplar (home centers will cut to length) or scrap plywood

Materials

QTY	DESCRIPTION
1	½" x 8" x 12" poplar or ¾" plywood (seat)
1	2" x 4" x 30" Hem-Fir (center support)
2	2" x 4" x 24" Hem-Fir (crossarm, steering arm)
4	2" x 4" x 18" Hem-Fir (runners)
4	¾" x 1½" x 24" PVC trim (runner face)

Instructions

● parent only
● parent and kid
● kid only

1. Measure and mark the 2 x 4s and the PVC trim to prepare them for crosscutting. Remember to mark an X on the scrap side of the line.
2. Crosscut the 2 x 4s and the PVC trim to length by cutting on the scrap side. If you have a scrap piece of plywood, cut the seat from it. Otherwise you can buy a short piece of poplar.
3. Use a six-teeth-per-inch woodcutting blade in a jig saw to cut the 30-degree angle end on the runners.
4. Mark a line across the PVC trim at 10 inches and clamp it firmly in a vise at the line. Pull the PVC toward you to bend it at an angle just greater than 30 degrees so that when the PVC springs back slightly you'll get an exact fit. You can always use the runner to check the angle.
5. Mark the center of the steering arm and bore a ½-inch-diameter hole through it. Bore two ½-inch holes for the towrope, approximately 3 inches in from each end of the steering arm.
6. Screw the PVC to the runners, then screw the steering arm and the rear crossarm to the runners. Screw the center support to the rear runner.
7. Bolt the steering arm to the center support and fasten the towrope through the holes on the arm by knotting them.
8. Knot the towrope in place and screw the seat to the center support.



1



2



3



4



5



6



7



8

SEE PREVIOUS PAGE
FOR INSTRUCTIONS



STEERABLE SLED!

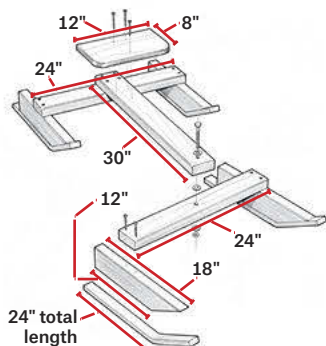
A project to build
with your children.

DESIGNED BY
JAMES SCHADEWALD

Difficulty:
Time: 4 hours **Ages:** 8+

PROJECT NOTES

OUR BIGGEST CONCERN with a sled made out of 2 x 4s was the weight. At about 20 pounds, this thing is a little heavy, but all you have to do is pull it over the snow, so that shouldn't be a problem. In our testing, the carriage bolt would occasionally loosen with the movement of the sled's front end, but you can fix that with a little bit of Loctite or superglue. The only other thing to fix was the friction. We worried that lumber wouldn't make for the most slippery surface—a problem we solved by adding the PVC board. The smooth plastic on the underside makes for a very fast surface. Rub some paraffin wax on it, and it'll really fly.



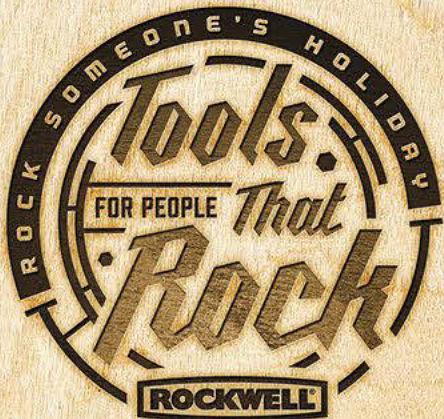
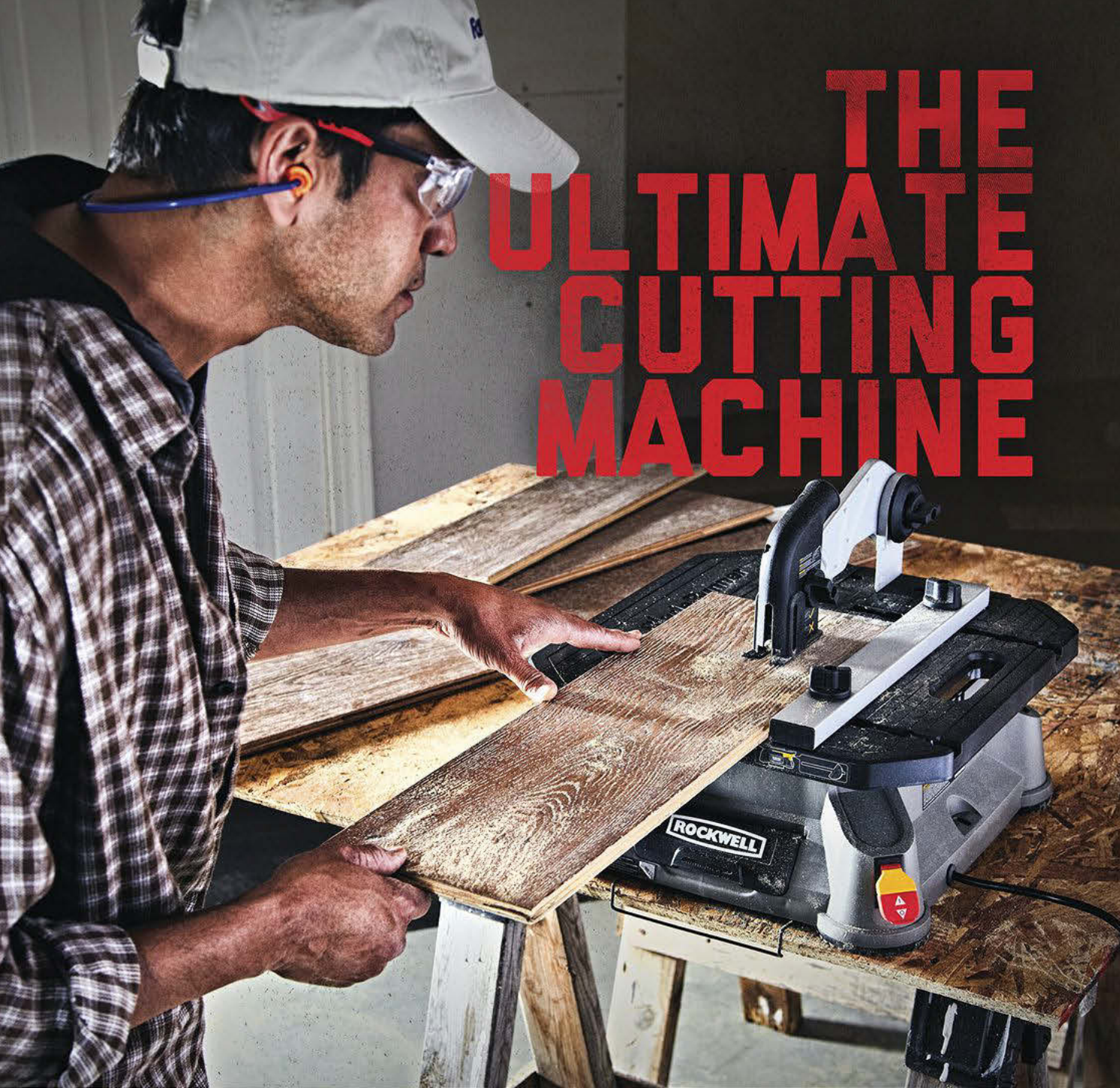
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